CIVIL ENGINEERING

Published by the American Society of Civil Engineers

Inner and Outer Harbor, Port of Los Angeles
Looking South Along the Main Channel from the West Basin

Volume 5 — AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852 — *Number 9*

SEPTEMBER 1935

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VOLUME 5 NUMBER 9

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

September 1935

Entered as second class matter September 23, 1930, at the Post Office at Easton, Pa., under the Act of August 24, 1912, and accepted for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on July 5, 1918.

CIVIL ENGINEERING

Published Monthly by the

AMERICAN SOCIETY OF CIVIL ENGINEERS

(Founded November 5, 1852)

PUBLICATION OFFICE: 20TH AND NORTHAMPTON STREETS, EASTON, PA.

EDITORIAL AND ADVERTISING DEPARTMENTS:

33 WEST 39TH STREET, NEW YORK

This Issue Contains

SUBSCRIPTION RATES

Price, 50 cents a copy; \$5.00 a year in advance; \$4.00 a year to members and to libraries; and \$2.50 a year to members of Student Chapters. Canadian postage 75 cents and foreign postage \$1.50 additional.

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VOLUME 5

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The Port of Los Angeles

An Account of Its Swift Rise to Third Place Among the Ports of the Nation

By GERALD C. FITZGERALD

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SITUATED in one of the few localities on the Pacific Coast where the mountains are sufficiently distant from the shore to permit of economic commercial development, engineering enterprise has charted the course of the port's phenomenal growth from an annual tonnage of 200,000 in 1899, when the San Pedro breakwater was begun, to a peak of 26,500,000 twenty-five years later. While it is evident that the vast mineral and agricultural wealth of Southern California would have necessitated a commercial outlet somewhere in the district in any event, nevertheless credit must be given to the human ingenuity and foresight which have ensured the well-planned and executed development of Los Angeles harbor as it is today. Completion of the Panama Canal in 1914 and the development of the oil industry in California must also be considered important factors in the growth of the port, which lies only a short distance off the great-circle route from Panama to the Orient. These and other facts are presented in detail in the following article, which has been abstracted from the address of Mr. FitzGerald before the Waterways Division on July 4, 1935, at the Los Angeles Convention of the Society.

THE Port of Los Angeles consists of two parts, as shown on the map, Fig. 1—an outer harbor, irregular in shape, formerly known as San Pedro Bay; and an inner harbor, formerly known as Wilmington Harbor. The main channel, 1,000 ft in width, leads from the outer harbor to a turning basin opposite Smith's Island. From the turning basin, narrower channels extend to the west basin and to the east basin; and the Cerritos Channel, which is 400 ft in width, extends from the east basin to Long Beach harbor. At the harbor entrance at the end of the breakwater the depth at mean low tide is 45 ft, while the depth in the principal channels and slips of both the outer and inner harbors is 37 ft.

Discussion of the Port of Los Angeles will be confined to the actual harbor area within city limits. However, this area does not include all the harbor. Reference to the perspective, Fig. 2, reveals that much of the eastern part of the harbor is under the jurisdiction of the City of Long Beach. The western boundary of Long Beach and the eastern boundary of Los Angeles are common throughout the port area.

Los Angeles harbor itself is one of the finest in the world. It is man-made, an engineering development. The two major contributing factors in its rapid development were the completion of the Panama Canal in 1914, and the development of the oil industry in the Los Angeles basin. This growth should continue because it has a good geographical location, with convenient land and water approaches, and a large potential tributary commerce. The harbor has, in addition, adequate and well-designed port facilities with proper administration and control.

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MAIN CHANNEL OF LOS ANGELES HARBOR
The Main Channel Is 1,000 Ft Wide and 37 Ft Deep

EARLY HISTORY OF THE HARBOR

Los Angeles harbor is one of the earliest ports of call for ships. It was visited in October 1542 by Juan Rodriguez Cabrillo, a Portuguese navigator sailing under the Spanish flag. He named it Bahia de los Fumos (Bay of Smokes) because of the presence of smoke from brush the Indians were burning on the hillside. Sixty years later, in 1602, Sebastian Viscaino, another Spaniard, visited the harbor and renamed it Ensenada de San Andreas. This was later changed to San Pedro. The City of Los Angeles was founded in 1781.

The first commercial transaction in the harbor took place in 1805, when the ship *Leila*

Byrd, of Boston, dropped anchor in San Pedro Bay to trade cloth, sugar, and household goods for hides and tallow from the missions. The *Leila Byrd* and other Yankee traders that followed her anchored in the open roadstead off what is now the lower reservation of Fort MacArthur.

Commerce continued at this site until Gen. Phineas H.

© Spence Air Photos

General View of Port of Los Angeles
Total Water Frontage Is Approximately 25 Miles

Banning between 1850 and 1860 founded Wilmington, the inner harbor, named in honor of his birthplace, Wilmington, Del. Here were landed most of the military supplies used during the Civil War and the Indian wars that followed. Use of the port by the Army brought about the construction, in 1869, of the first railroad in Southern California—from Wilmington to Los Angeles—and the launching, in 1871, by the United States Government, of the first comprehensive improvement program.

In the early eighties, the citizens of San Pedro and Los Angeles began an agitation for a breakwater to protect the outer harbor. Collis P. Huntington, then head of the Southern Pacific Railroad, desired to have the breakwater built at Santa Monica, 20 miles west of Los Angeles, where his railroad was in complete control of the waterfront. A long and bitter fight was waged until, in 1897, the decision was finally made in favor of San Pedro Bay by a board of government engineers. Congress then appropriated $2,900,000 for construction of the San Pedro breakwater.

At that time the whole area between the business section of San Pedro and Wilmington was a wide expanse of mud flats, practically all of which had been covered by tideland patents granted years before to private interests by the State of California. The question of the validity of these patents was raised in 1908 by the City of Los Angeles, and suit was brought in the name of the state against the tideland claimants. The actions were mostly successful. After the harbor district was brought within the city limits of Los Angeles, the tidelands were granted to the city to hold in trust for the people of the state.

The consolidation of the municipalities of San Pedro and Wilmington with Los Angeles in 1909 brought the port within the control of the latter and paved the way for large-scale port development. The development of the port up to the time of consolidation may be ascribed largely to private industry, with the exception of the work done by the federal government.

Up to June 1934, the federal government's expenditures on the Port of Los Angeles totaled $13,801,665. The principal projects were the development of jetties, dredging, storm silt diversion, widening the main channel, and construction of a breakwater and other units for government use.

The first government appropriation was in the amount of $700,000 for the construction of jetties in the vicinity of Dead Man's Island. These were for the purpose of establishing a reasonably permanent main channel entrance for light-draft boats. As the Southwest developed, additional jetties as well as deepening and widening of channels were required.

Construction of the San Pedro breakwater and lighthouse, which was the first major improvement, was begun by the government in 1899 and completed in 1912, at a cost of slightly over $3,000,000. This initial breakwater starts at Point Fermin and extends southeast and east a distance of 2.11 miles.

At the time the breakwater was completed fewer than 3,000 ships entered the harbor annually, and commerce slightly exceeded 2,000,000 tons. In recent years ship arrivals have averaged over 8,000 annually, and cargo has amounted to some 25,000,000 tons. This increase in traffic created an urgent demand for berthing space and sheltered anchorage grounds in the outer harbor, which could be provided only by an extension of the breakwater. Construction of an extension long enough to entirely enclose the outer harbors of Los Angeles and Long Beach was finally started in the latter part of 1932. The estimated cost of the project is $8,346,000.

The new breakwater will be an elongation of the outer arm of the existing one—leaving a 2,000-ft opening east of the lighthouse—and will extend in a straight line for a distance of 12,500 ft to a point due south of the westerly line of the Los Angeles flood control channel, east of Long Beach harbor. Two breakwater contracts have already been awarded for units totaling 5,400 lin ft and involving an expenditure of $2,220,000.

Fig. 1. Los Angeles Harbor and Vicinity in 1934

Rock for the breakwater construction is obtained from Santa Catalina Island and is transported on barges. Additional armor rock is obtained near Riverside on the mainland. Material for the clay base of the breakwater extension was dredged at a cost of approximately $105,000 in widening the main entrance fairway.

The government has also reclaimed approximately 69 acres of tide and submerged lands. It has dredged the entrance channel and turning basin and has nearly completed construction of a lighthouse depot wharf and of a U. S. quarantine and detention station. Funds for a federal building to house the several governmental agencies functioning at the Port of Los Angeles have also been made available.

CITY'S COMPREHENSIVE PLAN

From the time of the consolidation in 1909, the plan for development of Los Angeles harbor has had careful engineering study, the problem being so to plan for future growth as to avoid, as far as may be, the ills to which commerce is subject today in older ports. The basic plan, which has largely guided all the harbor improvements, is the system of bulkhead and pierhead lines laid out by the federal government in 1908.

The consolidation agreement was perhaps the first indication of an attempt to adopt an economic policy. It provided that the three cities be consolidated so that a port of free commerce could be developed under the control of one municipal corporation able to bear the burden of development. It also provided that there be expended for improvements at least $10,000,000 within the next ten years.

The first engineering study for the physical development of the port was conducted in 1910 by Homer Hamlin, M. Am. Soc. C.E., then city engineer, who tentatively outlined wharf and shed construction. In 1911 a report was made by Franklin D. Howell, M. Am. Soc. C.E., on a proposed railroad to be municipally owned and operated, which would completely serve the port and extend to the center of the city. In 1912 E. P. Goodrich, M. Am. Soc. C.E., prepared a report on harbor development. The ultimate bay-front development and breakwater extension of the present day is a reflection of the layout proposed in the Goodrich report.

During the period from 1912 to 1925 terminal facilities were planned and constructed at strategic points as need arose, without the adoption by the Harbor Commission of any comprehensive plan. The greatest care was observed to make permanent construction a part of the tentative plan based on the earlier studies.

In 1925 the Greater Harbor Committee of Two Hundred made a study and prepared a comprehensive plan to guide future development. It proposed the revision of the west basin development, removal of the drawbridge and railroad, some changes in slips and moles in the rest of the harbor, and a unified system of rail transportation to serve the entire port from Long Beach to San Pedro, eliminating both the West Basin and Long Beach drawbridges. They also fostered the study of arterial highways to serve the port. Important outgrowths of this study are the purchase of a tract of land for a future railroad classification yard to serve the entire port, and the present Harbor Belt Line Railroad agreement.

The present Los Angeles City Charter, which became effective July 1, 1925, places the administration of the port in a Board of Harbor Commissioners, the five members of which have overlapping terms of five years each. The board appoints a general manager, a secretary, and a chief accounting officer designated as controller. The Board of Harbor Commissioners has control of the entire city waterfront, of all navigable waters, and of all tidelands and submerged lands situated below the line of mean high tide within the limits of that part of the city north and east of the government breakwater. This area is known as the Harbor District.

WHARVES AND SHEDS ARE MOSTLY CITY-OWNED

Approximately 95 per cent of the wharves, sheds, and other port facilities, which are available to the public, are

FIG. 2. PERSPECTIVE VIEW OF LOS ANGELES METROPOLITAN AREA

owned and operated by the City of Los Angeles. The municipal wharves, which are modern in design and construction, have a total length of 44,582 ft. Of this total, 31,993 lin ft are of timber deck construction supported by creosoted timber piling; 10,639 ft, of composite concrete and timber design; and 1,950 ft, of reinforced piles with concrete deck. The city also owns and operates 24 transit sheds having a combined length of 16,207 ft. With two exceptions, these sheds are of the one-story type.

In addition to shedded wharves for the handling of general cargo, and open wharves and areas for special industrial uses, the port maintains a basin at the southwestern end of Terminal Island for the exclusive use of the fishing industry. This basin consists of an enclosed area of about 96 acres, well protected by secondary breakwaters. Along the north and west sides of the basin are located fish canneries, boat building and repair yards, dry docks, and oil and ice-servicing stations for the use of the harbor's extensive fishing fleet. Elsewhere in the harbor are located motor-boat marine service stations, public boat landings, U. S. Navy landings, a Coast Guard wharf, a wholesale municipal fish market and wharf, a landing and yard for livestock, and a cotton compress. Adequate fire protection is afforded by three modern fire-boats and ten land companies. The harbor further serves as the base of major units of the U. S. Fleet. With the exception of one open wharf set aside for the handling of lumber, all lumber wharves are adjuncts to privately operated lumber yards.

The aggregate length of private wharves is 21,864 ft, all of timber construction with the exception of 450 ft of concrete.

WEST BASIN TERMINAL

The latest addition to harbor facilities is the West Basin Terminal, completed in 1932. This consists es-

sentially of a combination reinforced concrete and timber wharf, 1,470 ft in length, and a double transit shed, 120 ft wide and 1,008 ft long, constructed of steel and concrete. That part of the wharf deck under the transit shed is of reinforced concrete supported on concrete piling. The bulkhead retaining the earth-fill is constructed of impregnated reinforced concrete sheet piling stayed by substantial concrete anchors.

© Aerial Mapping and Surveying Company

OUTER HARBOR, SHOWING SAN PEDRO BREAKWATER WITH EXTENSION

Fronting the concrete section outside the transit shed, a typical 31-ft apron wharf was constructed. A 10-ft loading platform is provided at floor level along the land side of the transit shed. The exterior of the reinforced concrete walls of the transit shed have been gunited and finished in old Spanish effect.

WAREHOUSES AND OTHER FACILITIES

Warehouse No. 1, located on Pier 1 in the outer harbor, is a Class A reinforced concrete structure of six stories and basement, with a floor area of 11 acres. Warehouse No. 2, immediately to the north, is a one-story building having a floor area of about 75,000 sq ft. The two municipal cotton compresses, also on Pier 1, are modern high-density steam presses, costing $150,000. Each has a capacity of over 60 bales per hour. A reinforced concrete building 750 by 150 ft, representing an investment of $225,000, provides space for the storage of 70,000 bales.

The port has two large plants, privately owned and operated, for the building and repair of sea-going vessels, as well as a number for the building of smaller craft. The large plants operate floating dry docks with lifting capacities of 12,000 and 15,000 tons, respectively, and marine railways for handling smaller craft.

Ten oil companies maintain bulk terminals at the harbor, operating with one exception over municipal wharves. A typical marine oil terminal usually consists of a tank farm, surrounded by fire wall, pumping plant, and administration building, faced by a narrow timber wharf on deep water, and equipped with fixed and flexible pipe lines for loading ships.

ENGINEERING LABORATORY

In connection with the problems of harbor construction and maintenance, the engineering division operates a laboratory for testing and research work. Aside from routine testing and inspection, the principal studies are waterproofing of concrete for marine use; paving for transit sheds; paint; wood preservation; roofing problems; and nuisances, such as oil and gas pollution, odor elimination, and fish cannery wastes.

Three main types of concrete piling have been used by the harbor department since the beginning of its development in 1910: pre-cast reinforced concrete piles, gunite piles, and asphalt-impregnated concrete piles. Asphalt-impregnated concrete was specified for the West Basin terminals, and asphalt-impregnated pre-cast sheetpiling for the fish-harbor mole. Research and improvement in concrete design and plant processes have made it possible to impregnate a strong, dense concrete under a maximum temperature of not more than 260 F.

RAILROAD, HIGHWAY, AND AIR TRANSPORTATION FACILITIES

Los Angeles harbor is now equipped with a belt-line railroad which renders rail transportation service to and from all steamship piers and industries. Prior to the inception of the belt line, the city had developed its harbor up to the point where it owned 57 miles of railroad trackage serving the industries and wharves. This trackage, however, was not in itself a complete unit. The port therefore entered into an operating agreement for joint use with the railroads of the desired connecting trackage links and other extensive railroad facilities within the harbor district. By virtue of this agreement, all railroad facilities lying within a specified area at Los Angeles harbor, and comprising 127 miles of trackage, were consolidated into a single terminal railroad unit. Unified operation of the railroad facilities was started in June 1929, under an independent and neutral operating management known as the Harbor Belt-Line Railroad. The control and management of the railroad is vested in a Board of Control and Board of Operation, giving the city equal voice with the railroads in the control of all the railroad properties at the harbor.

Augmenting the rail facilities, motor-truck transportation over five major and several lateral distributing highways handles more than one-half the total tonnage of lumber and general cargo to and from the harbor. This heavy truck movement is made possible by the equitable climatic conditions, which permit truck operation on a 24-hr schedule every day of the year and by the proximity of the harbor to the source and destination of much of the cargo. The business center of Los Angeles is about 20 miles from the port, but many large industries are located not over 10 to 20 miles away, and can truck directly to and from ships.

Los Angeles harbor airport, located on a 410-acre site on the south side of Terminal Island, was constructed in 1928, primarily for naval and military use. However,

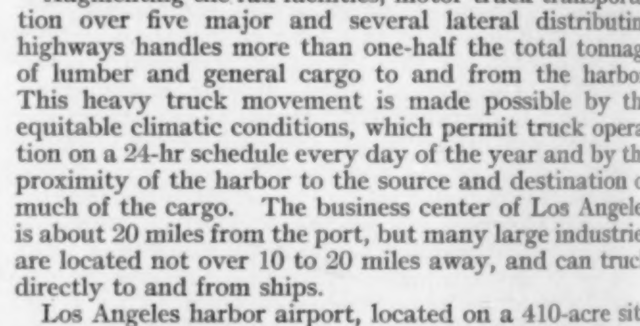

FIG. 3. VESSELS ENTERING PORT OF LOS ANGELES

Chart Showing Total Number of Vessels and Number of Foreign Vessels

the rapid development of aviation, manufacturing, and flying in the Los Angeles area and recent trans-Pacific flights indicate probable commerical usage on a large scale. To meet this demand, the harbor department is constructing additional facilities, which will cost about $175,000. The port authority has recently entered into an agreement with the California Institute of Technology, under which there will be established at the airport a modern marine meteorological observatory for scientific research in meteorology, aerology, climatology, and physical oceanography.

DEVELOPING COMMERCE AT THE PORT

Commerce through the Port of Los Angeles has increased phenomenally in the past 14 years, due principally to oil and lumber shipments. This growth is indicated by increase in the number of vessels entering the port, as shown in Fig. 3. The greatest commercial year was in 1923–1924, when 26,553,066 tons were handled. For the fiscal year 1928–1929, the port showed nearly as good a record, handling 26,099,245 tons. For the year 1933–1934, the port handled 18,348,196 tons, an increase over 1932–1933, with a total of 17,850,906 tons (Fig. 4).

Due to curtailed operations, lumber receipts at the port have decreased since 1930 by approximately one-half, and the exportation of petroleum has declined markedly. However, there have been increases in tonnage of general cargo, a condition which is reflected in Los Angeles' increasing industrial activity.

For the year 1933–1934, lumber tonnage through the port was 3.65 per cent of the total commerce; petroleum represented 74.16 per cent; and general cargo, 22.19 per cent. By value, lumber cargo represented only 1.67 per cent, petroleum products 17.34 per cent, and general cargo 80.99 per cent.

Analysis of commerce for the past several years discloses that approximately one-fourth of the total tonnage of the port is foreign trade and three-fourths domestic. One-fourth of the tonnage is inbound, and three-fourths outbound. General cargo averages about one-fourth foreign and three-fourths domestic, with three-fourths of this classification inbound and one-fourth outbound. One-fifth of the total commerce, in value, is in foreign trade and four-fifths in domestic, while values of inbound and outbound commerce are approximately equal. In general cargo, approximately one-seventh by value is in foreign trade, the remainder being domestic. Two-thirds of this value is inbound, and one-third outbound.

At the close of the War only a very few unimportant deep-sea steamship lines touched this port, not counting the lumber carriers. Today there are in excess of 150 different steamship companies sending their vessels into Los Angeles, and these ships go all over the globe.

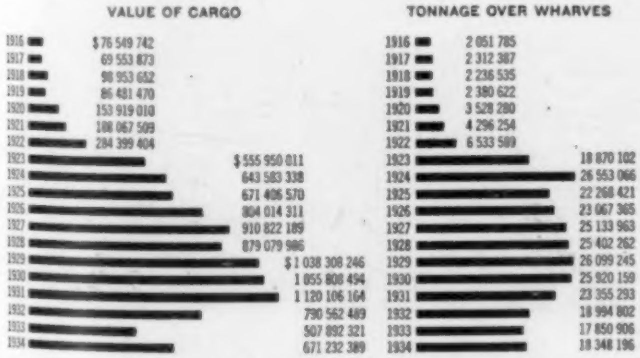

Fig. 4. Tonnage and Value of All Harbor Shipments
Dates Represent Fiscal Years Ending June 30

Investment by the City of Los Angeles in its harbor to June 1934 was valued at approximately $62,100,000, less reserves of $8,750,000. This includes a bonded indebtedness of $29,900,000, appreciation of $28,850,000 on tidelands, and about $3,500,000 from depreciation reserve funds and miscellaneous appropriations by the city. The net result, to June 30, 1934, is an operating deficit of $3,937,000, after taking into account operation, maintenance, depreciation, and interest. The deficit results from the fact that earnings are not yet sufficient to embrace more than about two-thirds of the interest burden. Much of the investment is in basic development, awaiting revenue-producing occupation. As such utilization increases, it is anticipated that a condition approximating full self-support will be reached.

ECONOMIC SURVEY OF PORT

The City of Los Angeles is definitely committed to the municipal ownership and operation of a harbor. The importance of the enterprise is revealed in the estimate of its worth in money circulation alone of over one hundred million dollars annually, and the fact that the value of cargo passing through the port exceeded one billion dollars per year during 1929, 1930, and 1931.

Comprehensive plans for the development of the port have brought about a reasonably definite physical policy. Until 1933, however, there had not been developed any definite economic policy. In order to clarify this situation and to place the administration of the port on a sound economic basis, the Board of Harbor Commissioners, in the early part of 1933, authorized an economic survey of the port. In May 1933, an outside authoritative and impartial group of consultants, known as the Board of Economic Survey, was engaged. It was the duty of this group to study the place of the port in the economic structure of the Southwest, and in the financial structure of the city. A Citizens' Harbor Survey Committee was also appointed, whose function was to act in a consulting and advisory capacity to the economic survey board.

Conditions required the completion of the survey within a very few months. It is regrettable that sufficient time was not available to permit of a more exhaustive study of the vital matter of rate structures, and that the contemplated survey of port facilities from an economic viewpoint and of port control and management had to be postponed. However, the port authority and interested civic groups welcomed the results of the survey. Some of the conclusions and recommendations of the Board of Economic Survey follow.

Oil and lumber will cease to be the major items in the commerce of the port, but general cargo has had a consistent growth, which should continue. The natural resources of the Pacific Southwest are far from completely developed. The port's primary purpose is to serve the community, not to produce profits. The Port of Los Angeles has not been completely self-supporting but should be made so as far as economically possible. The rate structure is limited by competitive conditions. The port authority should maintain control of port reserve funds, and not deplete them to relieve the tax burden. Among the more immediate necessary steps in the development of the port are advance preparation for revival of peak demand on facilities, the removal of the West Basin drawbridge, with provision for other means of land transportation to the West Basin, and the location of freight and passenger terminals along water frontage already developed. (Additional illustrations appear on pages 575 to 579.)

Colorado River Aqueduct Tunnels

Brief Record of Remarkable Progress Achieved by Developing Advanced Methods

By J. L. Burkholder

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Tunnel-building plants on the main Colorado River Aqueduct will have cost 13 contracting firms and the Metropolitan Water District of Southern California $10,000,000 when installation is completed. This paper reviews the work of constructing the vast aqueduct from the start in February 1933 up to about June 1, 1935. At that time the tunnels of the main aqueduct, aggregating 92 miles in length, on which ground was first broken in February 1933, were over 60 per cent completed. More than 71 miles had been driven, and the concrete lining had been placed in 9 miles. This excellent progress has been made in the face of some construction difficulties, of which that at the Potrero shaft is described—a heavy inflow from a shear zone across the tunnel, which held up that particular work for ten months. This paper is abstracted from a comprehensive treatment presented before the Construction Division on July 4, 1935, at the time of the Annual Convention of the Society in Los Angeles. Other articles on the Colorado River Aqueduct have previously appeared in "Civil Engineering"—in the May 1934 issue, page 240, and in the February 1935 issue, page 72.

The Colorado River Aqueduct, a $209,000,000 project for transporting water to the metropolitan area of Southern California, is scheduled for completion in December 1938. In addition to the tunnels, work is in progress on canal, conduit, and siphon construction, contracts for which were awarded late in 1934. By June 1, 1935, over 5,000,000 cu yd of earth and rock had been excavated, and 200,000 cu yd of concrete had been placed for open-work structures. A fairly extensive treatment of this entire project appeared in a symposium in the February 1935 issue of Civil Engineering, pages 72–86. Supplementing those articles, the present paper will be confined to certain features and problems met with in the tunnel construction.

As designed, the aqueduct will carry a flow of 1,605 cu ft per sec, or nearly one billion gallons per day. With a 7 per cent allowance for shutdowns, the average flow is 1,500 cu ft per sec. Tunnels, canals, and conduits are being constructed to full capacity initially, while most of the siphons are being built to one-half of the ultimate requirement.

Because of economic location factors, the hydraulic gradient and the corresponding diameters vary at different parts of the line. From the intake at Parker Reservoir to the West Portal of the San Jacinto tunnel, the tunnels and cut-and-cover conduit have a diameter of 16 ft 0 in. west of the San Jacinto tunnel. The tunnels and cut-and-cover conduit have diameters of 15 ft 3 in. and 15 ft $4^1/_2$ in., respectively.

Geology Affects Construction Methods

The geology of the mountain ranges traversed by the aqueduct tunnels is essentially complex. The formations penetrated include igneous, metamorphic, and sedimentary rocks, and range in age from Paleozoic to recent. The most prevalent encountered are intrusive granitic and dioritic rocks related to the Sierra Nevada Jura-Cretaceous intrusion. Locally, a considerable variation exists in the character of the igneous rocks. They are usually very hard and rather thoroughly jointed, particularly in the desert regions. Extensive sections of tunnel through these formations required support because of loose jointing or a local tendency of the rock to disintegrate in air.

Next most widely distributed are the older Paleozoic metamorphic rocks consisting largely of mica schist and gneisses with quartzite and crystalline limestone in less conspicuous masses. These rocks vary from soft to medium hard and are normally closely fractured. A large percentage of the metamorphic rocks encountered required support, and most of the "heavy ground" developed occurred at these sections.

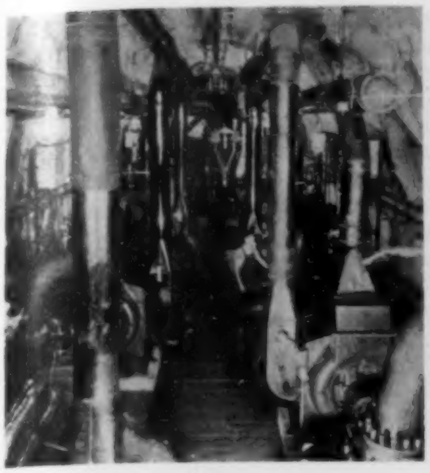
Three active major faults are intersected by the aqueduct line, in each instance in a direction almost normal to the strike and by means of a surface structure. The Mission Creek fault, an active branch of the notable San Andreas rift, is crossed by the Morongo siphon; the San Andreas fault is crossed by the San Andreas siphon; and the San Jacinto fault, by the Casa Loma siphon. Each of these siphons is an articulated reinforced-concrete structure.

Numerous dead or inactive faults were encountered in the various tunnels. The shear or crush zones accompanying these faults vary considerably in width, exceeding 100 ft in only a few instances. Such fault zones usually required heavy support, and quite frequently they required enlargement of section for heavier than normal lining. With but a few exceptions, no great difficulty was encountered in tunneling through the fault zones in the dry desert tunnels. However, in the San Jacinto and Valverde tunnels, where the faults are usually accompanied by a heavy water flow, they gave rise to difficulties which impeded progress considerably. An ancient river channel carrying considerable water was penetrated by the Valverde tunnel three times. Geophysical investigations were started when this channel was intersected the second time.

Processes of Excavation Developed

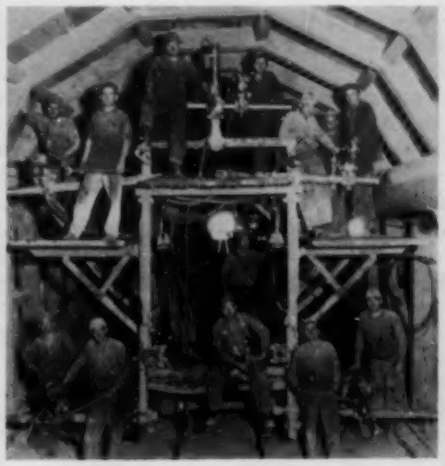
Twenty-nine separate tunnels varying in length from 338 to 96,605 ft comprise the 91.94 miles of tunnel. Con-

Offices and Housing for Engineering Staff
Headquarters of Division No. 3 at Eagle Mountain, near Desert Center, Calif.



Pump Chamber at Potrero Shaft; Total Capacity of Pumps, 15,000 Gal per Min

Man in Center Gives Scale of Size



Drill Crew on Carriage in Thousand Palms No. 1 Tunnel

Showing Five-Segment Arch Support

Liner-Plate Steel Support in East Iron Mountain Tunnel

This Curve Is on a 1,000-Ft Radius

tracts for 58.21 miles of tunnel were awarded, and the District elected to drive the remaining 33.73 miles by force account. Because the contractor on the 12.77-mile San Jacinto tunnel fell seriously behind his construction program, this work was taken over by the District on February 12, 1935. This increased the force-account work to 46.50 miles, leaving 45.44 miles to be built by contract.

Tunnel driving has been carried on from 58 headings, 19 of which are reached from 10 adits, totaling 11,890 ft in length; 12 from 6 vertical shafts, totaling 1,667 ft in depth; and 27 direct from the portals.

Excavation of the tunnels is ordinarily effected by the full-face method, using drill carriages. Excavating plants are designed for this method of work, and this fact is believed to account in part for the excellent progress. Because of poor rock structure, at times it has been necessary to abandon the full-face method and resort to a top heading and bench; or, if conditions warranted, the top-center drift method. In practically all the tunnels, short sections have been encountered where the full-face method could not be safely employed.

On the force-account work, the general practice for double-heading operations is to employ independent crews in each heading, rather than to alternate the drilling and mucking crews between two headings. The latter method is economical when the distance between headings is not too great and when the ground is uniform at both faces. It has been successfully used in the Whipple Mountain tunnel.

Although the full-face method has been generally adopted, it does not follow that there is uniformity in the drilling and blasting procedure. Rock formations control the depth of drill holes to a great degree, and each superintendent has his own ideas as to the best arrangement of the holes in the blasting round. The average consumption of powder on the Coachella force-account work has been 2.4 lb per cu yd excavated. A special gelatin dynamite with a low freezing point is generally employed, 40 per cent strength being used in the cut holes and 25 per cent in the others. In certain instances, 60 per cent strength is used in the cut holes. In the softer formations, the back holes are sometimes drilled but not loaded, and if the ground does not break to the holes, they are loaded and fired later. The Coachella tunnels may be cited as typical of overbreak conditions, which averaged 1.1 per cent beyond the pay line in unsupported ground and 7.2 per cent in timber-supported tunnels.

Four distinct types of supports—timber, steel, steel ribs with wood lagging, and gunite—are in general use in aqueduct tunnels. Each type has its special use. Of the 70.48 miles of tunnel excavated, 73.2 per cent has required support, of which 59.0 per cent is timber or steel, and 14.2 per cent gunite.

Timber support consists of five- or seven-segment arch chords supported by posts, wall beams being employed to support the arch segments where bad ground makes independent sets inadvisable. The timber is 10 by 10 in. and 12 by 12 in. under ordinary conditions, and 16 by 16 in. where extraordinary pressures are encountered. The sets are spaced to carry the required load. Where pressures require an increased thickness of the concrete lining, an enlarged section is excavated and the timber is set back to provide this.

Gunite is used to prevent air slacking and spalling of the rock rather than to support the tunnel. By early application it saves other more expensive types of support. It is placed in coatings usually of 1-in. thickness or less at a cost ranging from $1 to $3 per ft of tunnel.

Steel support is of two types. One consists of a two-section arch rib supported on wall beams and columns and lagged with pressed-steel liner plates bolted to the ribs; the other type, which was developed by the District forces, consists of two-segment I-beam ribs bolted at the top of the arch and extending to the sill blocks. The lagging is of wood. This type of support is proving to be very efficient and economical for many conditions.

WATER HAZARDS PRESENT

Both the San Jacinto and Valverde tunnels have encountered heavy flows of water. Since access to the headings in these cases was by means of shafts and inclined adits, pumping plants have been required to dispose of the water. The largest installations have been required at the Potrero and Cabazon shafts on the San Jacinto tunnel, where pumping stations have been designed to operate even though the tunnel and shaft should be completely inundated by a sudden inrush of water.

Because of the restricted working space in the vicinity of the shafts, independent bottle-shaped pump chambers were excavated, normal to the tunnel, to accommodate the pumps and motors. The Potrero chamber is 85 ft long, 19 ft wide, and 23 ft high, while the Cabazon

chamber is 60 ft long, 14 ft wide, and 18 ft high. These chambers are sealed from the tunnel by concrete plugs poured across the bottleneck. The plugs are provided with $4\frac{1}{2}$ by $6\frac{1}{2}$-ft doors of welded I-beams set 9 ft above tunnel grade, thus permitting removal of the pumps for repairs. This door, weighing about 8 tons, is so perfectly hinged that it can be moved by the pressure exerted by one finger. Within the large doors are small 24 by 31-in. doors designed to remain closed under all normal conditions and to give workmen ready passage to and from the chamber. Rubber belting in both door frames ensures watertightness.

At the Potrero shaft the pump installation consists of five units with a capacity of 2,600 gal per min, and two units with a capacity of 1,000 gal per min, the total rated capacity being 15,000 gal per min under an 850-ft working head. The larger pumps are four-stage horizontal units, driven by 700-hp motors, and the smaller pumps are six-stage horizontal units, driven by 300-hp motors. Each pump unit has independent electrical leads and push-button controls from a surface operating room.

To dissipate the heat generated in the sealed chamber from the 4,100-hp installation, duplicate cooling systems have been installed. These consist of air ducts leading to and from each motor, through which cooled air is mechanically circulated. The air is cooled by circulating clear water, taken direct from fissures in the tunnel, through a series of fin coolers around which the cooling air is circulated. The water temperature is about 70 F. This cooling system is the heart of the entire installation, and to ensure its proper functioning at all times duplicate parallel units with automatic control are so arranged that if the preferred unit should fail, the alternate unit is put into service. Should any pump motor become overheated, it is automatically removed from service, and this operation is signaled to the control room above.

Driving 70 miles of tunnel has not been without its difficulties. Ancient river channels and shear and crush zones varying in width from a few inches to 600 ft have been penetrated. In many instances these have carried heavy flows of water, and the advance has been extremely slow and hazardous. Squeezing and swelling ground developed in some tunnels, and this necessitated reexcavation to enlarge sections and the erection of heavier supports. In one instance heavy concrete lining was required to withstand squeezing on the sides and invert.

POTRERO SHAFT FLOODED

Experiences at the Potrero shaft on the San Jacinto Tunnel will illustrate the difficulties, as this was the most serious instance. A shear zone 160 ft east of the shaft (Fig. 1) delayed progress for ten months. On July 1, 1934, a flow of water estimated at 7,500 gal per min broke into the heading, carrying with it over 1,000 cu yd of debris. The station pumps, with a capacity of 2,500 gal per min, were immediately flooded, and the water finally filled the shaft to a depth of 647 ft. The shaft was dewatered on September 21, 1934. However, on November 17, 1934, before the debris had been cleaned up, the tunnel was again flooded. The second dewatering was completed on December 11 of that year. No attempt was made to remove the large amount of debris brought into the tunnel by the second flood, but timber bulkheads were constructed to hold this material at spring-line level so that driving by a top center drift could be commenced.

Active work on rehabilitating the timber supports in the flooded heading was resumed on January 15, 1935. In an attempt to lead the flow of about 6 cu ft per sec from the working face, a drift was excavated on the north side of the tunnel (Fig. 1), starting at a point 45 ft back of the face and extending to intersect the shear zone. This drainage diversion was unsuccessful, and an effort was then made to advance the main heading by a top center drift, using rails for spilling and breastboarding the face and sides. By March 4, 1935, the drift had been advanced only 6 ft.

Horizontal core-drilling was undertaken on March 5, 1935, for the purpose of exploring rock conditions in the immediate vicinity of the east heading. In all, 1,296 ft of drilling was accomplished. This work indicated a 50-ft width of the shear zone and accurately defined the strike of this zone. It also disclosed favorable rock and water conditions for a detour of the tunnel to pass through the shear zone about 125 ft south of the old heading.

POTRERO DETOUR STARTED

Work on the detour was actively started on April 8, 1935. A 10 by 11-ft tunnel (Fig. 1) was driven for a distance of 222 ft. Timber support was placed in the last 34 ft as a precautionary measure in case construction of a bulkhead became necessary while driving through the shear zone. At a point 20 ft from the zone, a rise was made for a 5 by 7-ft top center drift. As excavation in the drift advanced, 30-ft feeler holes were drilled ahead to test the formation and to locate water-bearing fissures. Where such fissures were encountered, grouting under high pressure effectively sealed off the water. This procedure made it possible to excavate through the crushed zone safely and without great delay or without materially increasing the total amount of water to be pumped The tunnel section in the vicinity of the shear zone is being excavated to provide for extra-heavy concrete lining from 15 to 30 in. in thickness. To safely support the running ground in the shear zone,

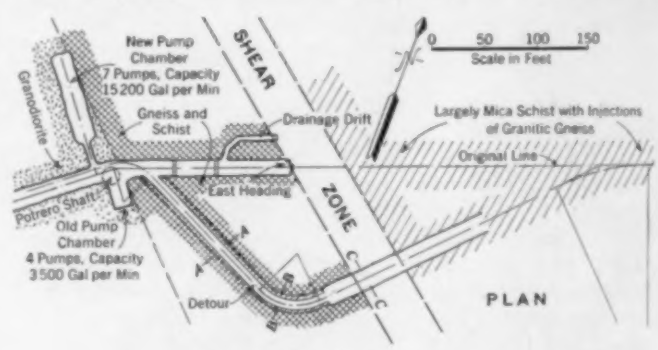


FIG. 1. POTRERO EAST HEADING, SHOWING TUNNEL DETOUR THROUGH SHEAR ZONE

it was necessary immediately to gunite a length of about 24 ft to a thickness of 24 in. An additional 6 in. of concrete will be added to this section during the normal tunnel-lining operations. To further ensure the safety of this section, 200 sacks of cement grout were forced back of the gunited section. The 222 ft of 10 by 11-ft tunnel is now being ring-drilled for enlargement to the full tunnel section.

Each contract is directly supervised either from the home office or from a regional office of the contracting firm located in the metropolitan area. All purchasing and general accounting work is accomplished in such offices.

As the work progressed, the field organizations gradually became standardized. The labor required per foot of tunnel advance decreased as the crews became better trained. At present, an average of about 30 man-hours is required per foot of tunnel advance under normal conditions.

COSTLY PLANT AND EQUIPMENT

With the completion of concrete-lining plants now in progress, it is estimated that the 13 contracting firms and the Metropolitan Water District will have expended more than $10,000,000 for plant in the construction of the main aqueduct tunnels, which are estimated to cost $58,000,000. Plant costs, therefore, represent about 17.5 per cent of the total cost. In all, $6,662,000 has been expended for tunnel excavation plant; $790,000 for building and equipping camps; and $455,000 for local utilities to serve the camps and construction work. In addition, the District has expended approximately $4,000,000 to make available water, power, communication, and highway facilities to the contractors and force-account work.

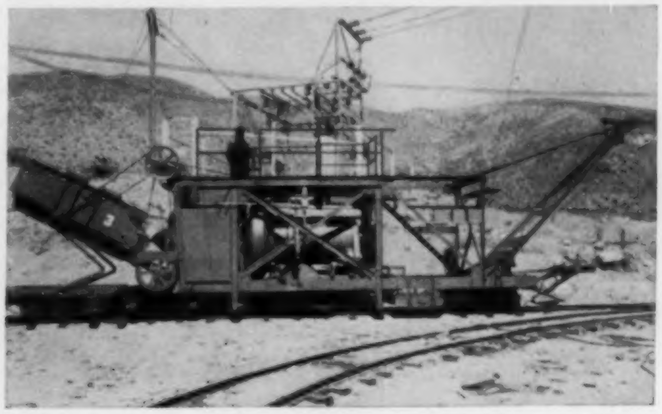
It may be concluded that an average depreciation rate of about $14 per ft of tunnel excavated is required to fully amortize the cost of tunnel-construction plant. This amount will vary somewhat from the average, depending on whether or not the camp and its operation cost are self-liquidating. The average cost of installed excavating plant for double-heading tunneling is $266,000, and for single-heading work, $148,000.

The purchase and erection of plants for lining the various tunnels with concrete have not as yet been completed, and neither total nor average costs for this work are available. Many of the contractors are subcontracting the production of aggregate, and several are purchasing these materials direct from producers.

The District has purchased and erected a concreting plant for lining 52,000 ft of the West Coachella tunnels at a cost indicated in the following tabulation:

Item	Cost
Gravel-pit equipment	$ 10,000
Crushing and screening plant	64,000
Batching and cement storage plant	9,500
Mixing and placing plant	21,000
Arch forms and jumbo	23,000
Batch bodies and miscellaneous tools and equipment	25,000
Total	$152,500

Heading the field construction personnel of the various contractors and of the District is a corps of highly trained tunnel builders who have organized and developed driving crews to take full advantage of the modern plant and equipment provided. These superintendents, walkers, and shifters deserve full credit for the excellent records attained on the construction of the aqueduct tunnels.



District's Plant at Wide Canyon, Showing Modern Equipment
At Left, Aggregate Plant; At Right, Pumpcrete Machine

The plant units which have been outstanding in assisting progress may be briefly mentioned, as follows: (1) efficient drill carriages facilitating full-face driving methods; (2) improved mucking equipment used in conjunction with large-capacity cars and time-saving switching devices; and (3) automatic and pneumatic drills with 30-in. carriages.

Over the entire aqueduct an average advance of 6.0 ft per shift, or 18 ft per day, has been made at 57 headings. An average shift advance of 6.9 ft has been made in dry tunnels and 3.1 ft in wet tunnels. Up to May 31, 1935, a total of 70.48 miles of tunnel, or 77 per cent of the entire project, had been excavated, and the equivalent of 9 miles had been completely lined with concrete. The outstanding daily record of 55 lin ft of full unsupported section tunnel in rock was made by the Walsh Construction Company on the Whipple Mountain tunnel. Forces of the Metropolitan Water District of Southern California completed 54 ft of full unsupported section in one day on the Seven Palms tunnel. The best weekly advance was made at West Iron Mountain tunnel by the Utah Construction Company, which drove 315 ft through cemented material in a seven-day week; 289 ft were driven through rock in a seven-day week by the Walsh Construction Company forces on the Whipple Mountain tunnel. A monthly record of 1,084 ft was made by the crews of the Walsh Construction Company on the Copper Basin No. 2 tunnel.

F. E. Weymouth is general manager and chief engineer of the Metropolitan Water District of Southern California; J. L. Burkholder, assistant general manager; Julian Hinds, assistant chief engineer; and James Munn, general superintendent. All are members of the Society. J. M. Gaylord is chief electrical engineer.

Observance of Traffic Control

A Serious Safety Problem Analyzed and Engineering Objectives Defined

In its early stages, highway traffic control was envisioned as largely a matter of enforcement. Naturally then, it was turned over to policemen, who were fairly successful for a time. With greater numbers of automobiles and vastly increased speeds, former methods of control have proved ineffective. The mounting accident toll is a tragic commentary on present trends and points to the basic reason for development of a new branch of the profession—traffic engineering. The two articles that follow indicate notable studies in this field.

In his analysis of traffic control devices and rules, Mr. Eliot's problem is to determine to what extent the various methods are, or ought to be, obeyed. From extensive records on these phases, he concludes the main problem is education and enforcement. In the second article, Mr. Lefferts cites methods used in Los Angeles, including pedestrian tunnels and a novel juvenile traffic school. He finds that the need of instituting traffic control and its efficiency when established may be judged in terms of accident records. Both of the articles are abstracts of papers delivered on July 4, 1935, before the Highway Division at the Los Angeles Convention of the Society.

Types of Regulation Affect Driving Habits

By William G. Eliot, *3d*

Highway Economist, Bureau of Public Roads, U. S. Department of Agriculture, Washington, D.C.

Safety in modern traffic has come to depend more and more on control and regulation. Strict regulation was first tried, but it soon became apparent that the motor vehicle could not be kept arbitrarily in the horse-and-buggy class. Then enormous programs of highway improvement were undertaken, mostly for the sake of faster and more comfortable travel, but with a hope that accidents might decrease. Traffic control devices were next developed as a means to a more orderly, and presumably safer, movement of vehicles. Through all the evolution of the new motorized type of transportation, regulation of vehicles and traffic has struggled to keep pace with rapid changes.

ANALYSIS OF THE PROBLEM NECESSARY

Just as the structural engineer determines the strength of his materials and their appropriate uses, so the traffic engineer must study the elements of his system to learn how far they can be depended upon, what weaknesses are likely to develop, and where a factor of safety must be allowed. To the extent that any control device or regulation is disregarded, it is useless or worse than useless. If it creates in anyone an unwarranted sense of security, it may actually increase the hazard that it has been designed to remove. On the other hand, if obedience to any form of traffic regulation can be secured consistently and can be depended upon, that form of control will constitute a constructive unit that can be incorporated into a definite and systematic program for greater safety.

Two objectives are sought by means of traffic control—to move vehicles safely and to move them expeditiously. To the motorist, any form of traffic control is a necessary evil at best, and it must be inherently reasonable to command his respect. Only strict police enforcement or an ingrained habit of obedience can secure the observance of a traffic regulation where it does not directly contribute to safety or public convenience. Many careful drivers of good personal character have no conscientious scruples about ignoring traffic rules where the rights and safety of others are in no way involved.

Accordingly traffic engineers must see to it that traffic control measures are reasonable and then insist that they be obeyed. A high proportion of non-observance reflects unfavorably on the traffic engineer. It may mean that he has attempted regulation where none is justified; that he has failed to educate his public to the recognition of an actual need; that he has provided inadequate police supervision; or that his control devices are not properly designed or placed to compel attention. This paper therefore is devoted to a detailed consideration of the obedience rendered by the motorist to five specific types of traffic regulation.

1. Speed Regulations. It seems safe to say that no traffic regulations are as generally ignored as those which attempt to prescribe proper speeds. The motor-vehicle operator drives at what he considers a safe pace, regardless of legal speeds, unless he has reason to believe that a speed limit is being enforced by arrests.

In Maryland in 1933 A. N. Johnson, M. Am. Soc. C. E., found that 13 per cent of the drivers traveled in excess of 45 miles per hr, despite a legal speed limit of 40 miles per hr. On highways in settled areas where the limit was 25 miles per hr, the violations reached 94 per cent.

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Rural as Well as Urban Districts Need Signals for Proper Control of Traffic

Scene at Important Intersection of U. S. Route 1 and Cranberry Turnpike in New Jersey

Data from the 1934 traffic survey in Rhode Island, in which state the legal speed limit is 35 miles per hr, show that 53 per cent of the vehicles recorded at 30 typical stations on open highways were traveling at speeds of 35 miles per hr and over, and 32 per cent at 40 miles and over.

In South Carolina 25 per cent of all vehicles timed on rural highways traveled in excess of the 45-mile speed limit. At five stations in built-up areas, where a speed limit of 20 miles per hr applied, average passenger-car speeds ranged from 24.7 miles per hr for local cars to 48.6 miles per hr for "foreign" vehicles.

The same disregard of legal speed limits is seen on city streets. In Knoxville (1934) 24 per cent of the passenger cars approaching intersections outside the central business district violated the 30-mile speed limit, and on residential arterial streets 39 per cent violated the 30-mile speed limit. In Memphis, from 13 to 60 per cent of the passenger cars approaching selected intersections exceeded the legal limit of 25 miles per hr by at least 5 miles per hr, while from 30 to 66 per cent of the light trucks, and from 15 to 66 per cent of the heavy trucks exceeded the 20-mile legal limit for commerical vehicles by the same amount.

Recognition of this widespread disregard has led a number of states to abolish speed limits altogether, substituting only the requirement that speeds shall be reasonable and proper. Such a change makes the law more difficult to enforce because it places on the arresting officer the burden of decision. Furthermore, there has been a growing opinion that the increased power and speed of automobiles in recent years demands a new type of speed limit. Regulations in the past have been determined primarily by the physical limitations of roads and vehicles. In the future we must consider the physiological and psychological limitations of the human species.

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OBSERVANCE OF LANE MARKINGS MEANS SAFETY

Treatment of Curves on Southern States Parkway, Long Island

Engineers can see no end to the improvement of cars and highways, but the human factor of safety has already been reduced to a very narrow margin.

2. *Caution Signs and Signals.* It is difficult to measure obedience to traffic-control devices when the only response expected or required is that the motor-vehicle operator shall proceed with caution. Studies of flashing amber-light caution signals during the Rhode Island traffic survey showed the apparent response to be in proportion to the hazards present. For practical purposes, any driver who reduced his speed to an estimated 15 miles per hr was tallied as obedient to the warnings. Nearly 42 per cent of all vehicles recorded were classed as violators. One observation station situated on a straight road reported 84 per cent of violations, as compared with 14 per cent at a station on a dangerous curve.

Despite the apparent disregard of cautionary warning devices, they are indispensable at points of danger. Since they impose no specific legal obligation on the motorist, a strict program of penalizing enforcement is clearly out of the question. It is possible, however, to

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CONTROLLED TRAFFIC IS ORDERLY TRAFFIC

Fifth Avenue in New York on Easter Morning, 1935

educate the motorist to a clearer understanding of their meaning and value. The new "Manual on Uniform Traffic Control Devices for Streets and Highways," prepared by a joint committee of the American Association of State Highway Officials and the National Conference on Street and Highway Safety offers an excellent basis both for an educational campaign and for a standardization of signs and signals.

3. *"Stop" Signs.* "Stop" signs are widely used at street and highway intersections. They are simple and their message is unmistakable, yet reports from widely distributed sources indicate a high degree of disregard for them on the part of the motorist, as shown in Table I. "Almost stopped" vehicles are those entering at an estimated speed of less than 3 miles per hr, and "entered fast" includes those exceeding 15 miles per hr. For practical purposes, the drivers of vehicles entering at

TABLE I. BEHAVIOR OF VEHICLES AT "STOP" SIGNS (PERCENTAGE)

Locality	Made Full Stop	Almost Stopped	Entered Slow	Entered Fast
Rhode Island	45	29	19	7
South Carolina	22	23	32	23
Chattanooga	25	48	21	6
Knoxville	27	39	29	5
Memphis	62	28	8	2
Nashville	49	31	15	5

less than 3 miles per hr, and presumably under full control, may be considered as obeying at least the spirit of the law. Some safety surveys have distinguished between drivers who stop voluntarily in obedience to the sign and those who stop because of cross traffic or vehicles ahead of them. Table II shows how violations increase when the driver is free to do as he pleases.

TABLE II. BEHAVIOR AT "STOP" SIGNS, AS AFFECTED BY INTERFERENCE, IN THREE TENNESSEE CITIES, IN PERCENTAGE

	Encountering No Interference				Encountering Interference			
Locality	Made Full Stop	Almost Stopped	Entered Slow	Entered Fast	Made Full Stop	Almost Stopped	Entered Slow	Entered Fast
Chattanooga	21	49	23	7	59	35	5	1
Knoxville	21	41	32	6	75	16	8	1
Memphis	60	30	8	2	68	24	6	2

The data in Table II do not speak well for the motor-vehicle operator. However, they also suggest the possibility that "stop" signs have been used too liberally, and regardless of the degree of hazard present. We are left in a dilemma, for safety on arterial highways, as such, depends entirely on an unquestioned determination of right of way. Any caution requirement short of a full stop opens the way to misunderstanding and accident.

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DRIVING AT HIGH SPEED IS TOO PREVALENT
This Car Went Through the Guard Rail on U. S. Route 90 near Aucilla River, Florida

4. *"Stop-and-Go" Signals.* The traffic light, or "stop-and-go" signal, is the most highly evolved type of traffic control. It definitely separates vehicular movements on a time basis, and if strictly obeyed prevents conflicting maneuvers. Violation of traffic-light signals is rare as compared with that of other forms of traffic control. Because they are specific in defining who shall move and who shall not move, the violator has no defense in case of accident, and police enforcement has been strict. Observance in various localities is indicated in Table III.

TABLE III. BEHAVIOR OF VEHICLES AT TRAFFIC SIGNALS, IN PERCENTAGE

LOCALITY	VEHICLES ENTERING INTERSECTION ON:			
	Green	Amber After Green	Red	Amber After Red
Rhode Island	97.0	2.2	0.8	...
South Carolina	95.9	0.9	3.2	...
Chattanooga	87.4	5.9	1.7	5.0
Knoxville	77.0	5.8	11.5*	2.5
Memphis	88.8	6.9	4.3	...
Nashville	89.3	6.5	1.8	2.4

* Excluding 3.2 per cent which legally turned right on the red signal after making a full stop, but including 7.8 per cent which turned right without stopping.

TABLE IV. COMPARISON OF FIXED-TIME AND VEHICLE-ACTUATED SIGNALS IN RHODE ISLAND, IN PERCENTAGE OF VEHICLES

TYPE OF LIGHT CYCLE	VEHICLES ENTERING INTERSECTION ON:		
	Green	Amber After Green	Red
Fixed-time	95.2	3.5	1.3
Vehicle-actuated	97.5	1.9	0.6

Vehicle-actuated signals, because they are more responsive to traffic needs, command a generally higher degree of observance (Table IV). Under conditions of light traffic they may accommodate individual vehicles so promptly that even deliberate disobedience would be difficult. Furthermore, since they do not cause prolonged, unnecessary delays, there is little irritation or desire to disobey created in the driver.

There has been much complaint about the excessive use of traffic-control signals. It cannot be questioned that the objectives of many existing signals could be achieved as well or better by other types of control, at least during certain hours.

5. *Rules of the Road.* Right of way at intersections, in the absence of any arbitrary traffic-control device, has never been satisfactorily defined. What ordinarily happens is that each driver uses his own judgment, and in case of doubt the bolder driver or the larger vehicle goes through first. It is surprising that collisions do not occur oftener under such conditions. More and more the right of way is being prescribed by "stop" signs or signals, rather than by general rules.

In contrast, the rules governing driving in the correct lane while passing and at other times are relatively simple. Head-on collisions are really extremely rare; that they do occur merely indicates that there are exceptions to the generally high degree of obedience. The greatest danger points are at curves and hill crests, where visibility of the road ahead is impaired In cities, the most serious lane violations are those involved in making turns at intersections.

Hand signaling for turning or stopping should become an automatic habit of every driver. Strict observance is not always essential to safety, except as it helps build up safe habits. A mechanically operated "stop" light is probably more effective as a warning of changing speed than a hand signal. In the absence of other vehicles, a signal is wasted, just as time may be wasted at a red traffic signal. Nevertheless, safety demands that every change of course or speed that might possibly interfere with other vehicles should be properly indicated in advance, and this means, in practice, universal signaling. Data from Tennessee surveys, in Table V, are instructive.

It is clear that there is a long way to go in building up safer driving habits. The man who is "out of step" in traffic has caused many a wreck. Better law observance, and better driving judgment, generally, make for safer highways. Probably the law violators are those whose driving ability is otherwise below standard. The idea must be emphasized that driving is a privilege, not a right—a privilege that can and will be withheld from those who do not show themselves qualified physically and mentally for the responsibility. A well-administered drivers' license law, requiring examination of prospective drivers and providing for suspension or revocation of licenses for cause, is the best means yet discovered for the application of this principle. Outside of occasional drives, we have not really "cracked down" on traffic violators, except in some notably exceptional communities.

TABLE V. OBSERVANCE OF HAND-SIGNALING REGULATIONS IN TENNESSEE, IN PERCENTAGE

LOCALITY	NO SIGNAL	IMPROPER SIGNAL	PROPER SIGNAL
Knoxville	79	6	15
Memphis (left turns only)	48	24	28
Chattanooga	74	..*	26
Nashville	79	6	15

* No exact form of signal prescribed by law.

Perhaps too much has been expected from the motorist. The traffic engineer cannot feel too sure of himself when public opinion as expressed in driving behavior does not stand squarely behind him. Whatever the cause of the laxity, however, the need for improvement cannot be denied. First of all, the traffic engineer must satisfy

himself that his traffic control devices and regulations are necessary and proper; then he must promptly undertake a really active program of education and enforcement to secure the safety and order that are the corollary of obedience.

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A Traffic Safety Survey of the City of Chattanooga, Tennessee, 1934 (mimeographed), The Commissioner of Fire and Police, Chattanooga, Tenn.

A Traffic Safety Survey of Knoxville, Tennessee, 1934 (mimeographed), The Director of Public Safety, Knoxville, Tenn.

Traffic Safety Survey of the City of Memphis, Tennessee, 1934 (mimeographed) The Commissioner of Fire and Police, Memphis, Tenn.

A Traffic Safety Survey of the City of Nashville, Tennessee, 1934 (mimeographed), The City Planning and Zoning Commission, Nashville, Tenn.

Accident Studies Show Means of Improvement

By E. B. Lefferts

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VEHICULAR traffic as a problem on streets and highways is of such recent origin that we are only beginning to learn how to cope with it. The great toll of human life which it annually takes demands that every effort be made to find a solution. Also its economic phases are a factor of no small moment.

That traffic control is a problem of enforcement is still quite generally believed, which undoubtedly is the reason why the average person thinks of it in terms of police activity. While such activity is important it is very doubtful if any program of enforcement can effect 100 per cent obedience of regulatory devices improperly placed or of regulations that appear illogical. One of the most accurate measures of the successful solution of a particular traffic engineering problem is its effect on accidents. In fact, at present, accident studies are one of the essential factors that must be considered in connection with nearly all traffic problems.

Also the pedestrian phase must be studied. Regulation of foot traffic has a very definite bearing on the accident situation, particularly in urban areas, as well as on the expeditious movement of vehicular traffic. Ten years ago in the City of Los Angeles an ordinance was passed making "jaywalking" an offense under the traffic law, punishable by fine or imprisonment. Without any change in the timing of the traffic signals, an increased number of vehicles were able to pass through the intersections on each signal interval, and the time necessary for a vehicle to traverse the congested district was reduced materially. Still more gratifying is the lowering of the percentage of pedestrian deaths.

A Controlled Intersection at Los Angeles

Depicts How Well Pedestrians Can Obey Traffic Signals

To obtain general compliance with such a regulation, something more than just the enactment of the law is necessary. One of the requisites is public support; that is, there must be a sufficient volume of vehicular traffic to make pedestrian regulation seem reasonable. Another fundamental is that the traffic signals be operated on as short a cycle as possible. As a rule the cycle should not exceed 72 sec, and shorter timing is desirable. If the interval is too long the pedestrian will "take a chance" rather than wait. In the majority, human beings are reasoning individuals; therefore, unless regulations appeal to general common sense, it is practically impossible to obtain compliance regardless of how strenuous the attempts of the police may be to enforce the law.

As a further means of protecting pedestrians, particularly children, in the City of Los Angeles alone 78 pedestrian tunnels have been constructed in the vicinity of schools, where large numbers of children must cross busy thoroughfares. The saving in salary of a police officer necessary to guard the crossing pays the interest on the investment. The savings to the tens of thousands of motorists have not been calculated but would total a substantial sum. Traffic checks show that from 90 to 100 per cent of the children use these underpasses, but that less than 10 per cent of the adults follow their example. The reason for the general use by children is to be found in the very strict supervision by the school authorities to insure compliance with their mandate prohibiting pupils from crossing on the surface, if tunnels are provided. Because there is ample justification for their insistence on the observance of this rule, they have the essential parental support.

Los Angeles Has Developed Pedestrian Subways

An Effective Protection for School Children Who Must Cross Heavily Traveled Streets

Following a period of increased police activity, a reduction in traffic accidents invariably results; hence it appears that the development of a fear psychosis must be the cause of this temporary improvement. In one study covering 32 cities, the 18 that increased traffic arrests obtained a reduction of 13 per cent in traffic accidents; while the 14 in which enforcement was not increased, experienced an increase of 5 per cent in such accidents.

At least one of the probable causes for failure to observe the traffic regulations is ignorance of the laws. The answer of course is education. I am glad to state that educators generally are instituting courses to eliminate this ignorance, so that in the face of a general increase in accidents during the past 12 years, the trend for children of school age is generally downward. In Los Angeles traffic regulations are taught to all boys and girls in the ninth grade, where the average age is 15, just one year before they become eligible for a driver's license.

A further indication that education is an important

factor is found in the recent accident record of commercial vehicles. While the passenger vehicle has been involved in an increasingly large number of accidents, accidents to commercial vehicles have been decreasing. The educational activities of employers, designed to inform the drivers of their fleets regarding traffic rules, together with the use of adequate discipline when necessary, has been the means of effecting this improvement.

PLAYING A "STOP-AND-GO" GAME
Children Learning to Observe Traffic Signals

In Los Angeles the Juvenile Traffic School is well known. It was instituted in March 1931 after many conferences between the judge of the juvenile court, the probation department, the school department, and the automobile club, to serve an educational as well as a disciplinary purpose. If a monetary penalty is inflicted on a juvenile offender, the payment usually is made by the parent and no corrective effect is produced on the actual culprit. It was to correct this situation that the traffic school was developed. This school is coeducational, there seeming to be no sex distinction in the violation of traffic laws. Sessions are held every Saturday from 10:00 a.m. until noon. A sentence to the school necessitates attendance for four successive Saturdays. During each 2-hr session a thorough explanation is given of certain sections of the vehicle code, followed by discussion and a written examination. To obtain a "certificate of completion," which is the necessary clearance, an average grade of 75 per cent must be obtained in the written examinations. In addition to the educational feature, there is a disciplinary one; the sacrifice of four Saturday mornings by the 3,800 boys and girls who have been compelled to date to take the course during the past four years has not been forgotten. A similar plan of intruction also has been followed for certain adult offenders.

The licensing of drivers presents an educational opportunity that has not been sufficiently emphasized as yet, even in those states having standard laws. Such studies as have been made show that a relatively small percentage of the drivers are responsible for a great majority of the accidents. From present data it appears that some of those involved in traffic mishaps can be retrained or educated so that they will drive safely; the remainder should be barred permanently from endangering themselves and others on the highway.

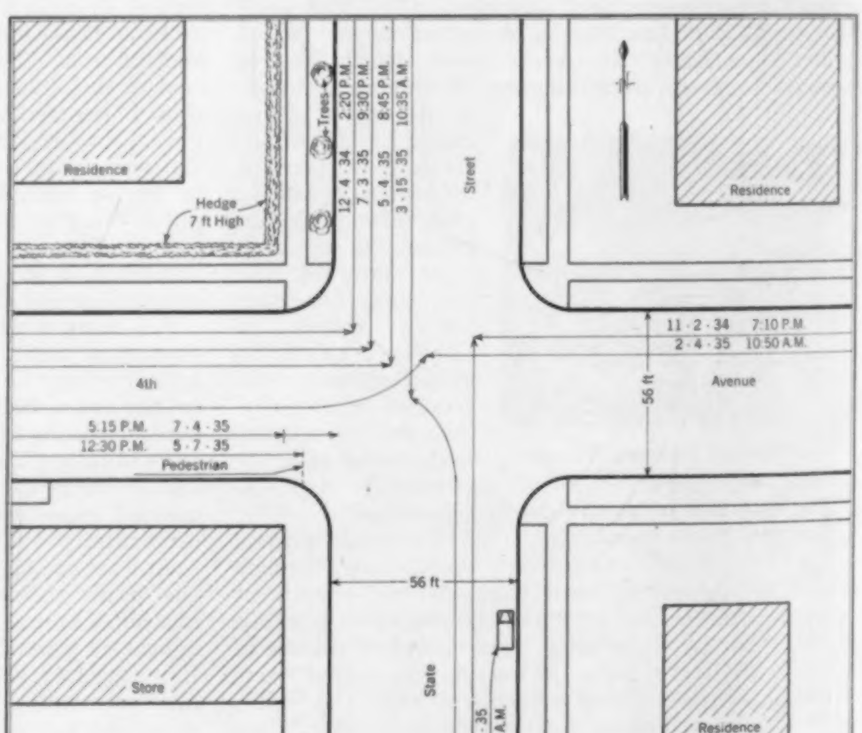
Because of the lack of adequate study beforehand, frequently conditions are aggravated by the installation of a control device. One study of 354 locations revealed that accidents increased at 38 per cent of the intersections after the devices were installed. Other studies showed that at some intersections 23 per cent of the vehicles were "running the red light." Before it is concluded that all these drivers are anti-social, the locations should be subjected to careful study to determine whether the signals are placed properly, whether they are visible under all conditions, and whether their placement is justified. Most drivers will cooperate by observing the regulations, as indicated in Table I, and when a substantial percentage are found to disobey, careful study should be undertaken to determine the cause.

TABLE I. RESULTS OF INSTALLING BOULEVARD STOP SIGNS IN LOS ANGELES

Location of Sign	Vehicles per 24 Hr	Days Before Control	Accidents Before Control	Days After Control	Accidents After Control
No. 1	15,500	550	11	550	0
No. 2	14,406	961	22	961	1
No. 3	15,000	419	17	419	1

Highway engineers have endeavored to make the highway as safe as possible and to reduce to a minimum the need for warning devices that must be observed. Automotive engineers have provided a safe vehicle. The police and the courts also have been striving to make the highways safe through penalizing those apprehended in failure to observe control devices and regulations. Yet there is a mounting accident rate, which must impress us with the ineffectualness of such efforts, and should provide sufficient justification for a trial of something new and different.

Today emphasis is placed almost universally on technical violations, with particular concentration on speed and little if any consideration of the original causes of collisions. With a careful investigation of all accidents, and the imposition of adequate penalties on those found to have violated the regulations, a different attitude would soon be developed toward all regulatory devices. This placing of the responsibility where it belongs—on the person who causes the accident—would result in a much more general appreciation of the reasons for the regulations, and ultimately would bring about the observance so generally desired.



COLLISION DIAGRAM AIDS IN ANALYZING ACCIDENTS TO FIND BEST TRAFFIC CONTROL EQUIPMENT

Past, Present, and Future in California

Natural Conditions Provide Stimulus for Engineering Achievements

GREAT physiographical differences and extreme variations in rainfall within a limited area have made California an ideal field for engineering endeavor. Menacing floods must be controlled and conserved to relieve the effects of the dry season. The lack of sufficient harbors has necessitated the construction of a man-made port. Mr. Conner's historical paper, tracing land ownership from the early mission fathers under the flag of Spain through the Mexican land grants to the period of American control, paints for the symposium a background full of the atmosphere of pioneer days. The second of the four articles, by Mr. Sonderegger, shows how the topography of the state has had a far-reaching effect on the development of its people. In a study of past and present engineering activity in California, Mr. Lippincott has in effect written an outline of engineering achievement in the state. The fourth contribution, by Mr. Goudey, is a survey of engineering problems likely to arise in the near future and of present problems whose solution is not yet complete. All four of these articles are abstracts of papers that were delivered on July 3, 1935, at the Los Angeles Convention of the Society.

The Romance of the Ranchos of California

By Palmer Conner

Assistant Secretary, Title Insurance and Trust Company, Los Angeles, Calif.

ONE hundred and fifty years ago the mission fathers first brought their civilization to California. Within fifty years they had built a chain of missions extending from the Russian settlement in northern California to the border below San Diego. With them came the Spanish soldiers, sent to protect the missions, the settlements at the ports, and the pueblos as they were founded. It was never anticipated that these soldiers would stay and colonize the land. Yet the history of the early Spanish grants (Fig. 1) shows that this is what happened. If we go back far enough, we find the ownership of some of California's best land founded on the particularly illustrious deed of a Spanish soldier. The first of all the grants in California was that of the large Rancho San Rafael, including the area now comprising Glendale and the Eagle Rock district of Los Angeles. It was granted in 1784 to Jose Maria Verdugo, Corporal in the King's Army, in recognition of an act of bravery.

When they received grants of land the dons built adobe structures, grazed their cattle, and settled down on the land. They named their ranchos for tree or stream or mountain, bird or patron saint, and sometimes for themselves. In some cases, through 150 years, under three governments, and in two languages, an unbroken chain of title can be traced from these Spaniards to the present-day owners. Many towns, cities, and communities of California have been named for the rancho on which they have been built. The Rancho San Fernando gave its name to the town of San Fernando, and Santa Monica, Tujunga, Azusa, Palos Verdes, and Santa Ana were named in the same way.

To encourage colonization, the government of Spain planned pueblos—"little towns"—and urged people to immigrate and settle on the land. Grants were made to four pueblos in Southern California—to San Diego, Santa Barbara, San Luis Obispo, and Los Angeles. Of course it required no act of bravery to obtain property in a pueblo. The Spanish law provided that any settler was entitled to possession and title. But one had to be a great Spanish don to receive a ranch grant. Within the grant to the Pueblo of San Diego is Balbao Park, where the new World's Fair has been built, and this 1,400-acre park has always been the property of the

Mission de San Fernando, Center of a Grant of 121,000 Fertile Acres

Later Sold Under Military Necessity for 11 Cents an Acre

city. It traces its title directly to the pueblo's grant by the King of Spain.

In 1821 Mexico in her first revolution threw off the yoke of Spain and gained her independence, but owing to the remoteness of California and the lack of communication facilities, it was not until the following year that Californians learned they were no longer subjects of Spain, but a part of the Republic of Mexico. After that date the control of California land passed to the Mexican governors, who parceled out the remaining good land in California to their subjects—more often for money or military support than for bravery. These grants are the Mexican land grants in California.

Since the mission churches were more closely linked to Spain than to Mexico, shortly after California came under Mexican control the great conflict began between these churches and the Mexican Government, ending in some cases in complete abandonment of the missions. By 1840 many of the mission buildings were in ruins and the mission lands granted to them, supposedly in perpetuity by the King of Spain for their maintenance and support, had been seized by the Mexican Government and regranted.

Greatest of all the lands of the mission churches taken over in this manner were those of the Mission San Fernando—121,000 acres extending from mountains to mountains on all sides of the San Fernando Valley. Although seized by the Mexican Government, this huge ranch was held intact until 1846. In that year armed invasion of California was commenced by the Americans. Governor Pio Pico, the last of the Mexican governors, desperate for funds with which to equip an army and combat the invaders, asked permission of his government to grant Rancho San Fernando. In this emergency it was sold for $14,000, approximately 11 cents an acre. Doubtless Pio Pico made this grant with great regret, for all indications point to the fact that he desired to add it to his own vast holdings. He placed a provision in the deed that if within eight months the Government of Mexico could raise the $14,000, the money should be refunded and the land revert to the government. But the Government of Mexico in California and of Pio Pico itself did not last eight months, and within that time Pio Pico, defeated and humiliated, had fled to Mexico. He subsequently returned and became an American citizen.

The last grant of land made by Pio Pico, and subsequently confirmed by the United States, was the grant of Isla Santa Catalina, made July 4, 1846.

The conquest of California under Commodore Sloat, Commodore Stockton, Colonel Fremont, and General Kearney was short, swift, and decisive. In 1848 the war was settled by the Treaty of Guadalupe Hidalgo, in which it was provided that the Spanish and Mexican land grants in California should be protected by the United States. But even as late as 1849 the value of California was little known in the eastern part of the country. On March 5, 1849, the day of his inauguration, President Zachary Taylor stated that California was too remote and of too little value to be worth retaining. In that same year, however, occurred the greatest gold rush in the history of the world, and a billion dollars in mineral wealth was uncovered in California.

AMERICANS PLAN DEVELOPMENT

In 1850 California became a state; Los Angeles County was formed; and the Pueblo of Los Angeles became the City of Los Angeles. The county area was then much larger than at present, extending from Santa Barbara on the north to San Diego, and from the Pacific Ocean to the Colorado River. In that year the first county election was held, with polling places designated at the six most prominent and convenient locations in the county. The election notice concluded by stating that the polls would be open from 9:00 till 11:00 a.m., so that all those eligible could have a chance to vote!

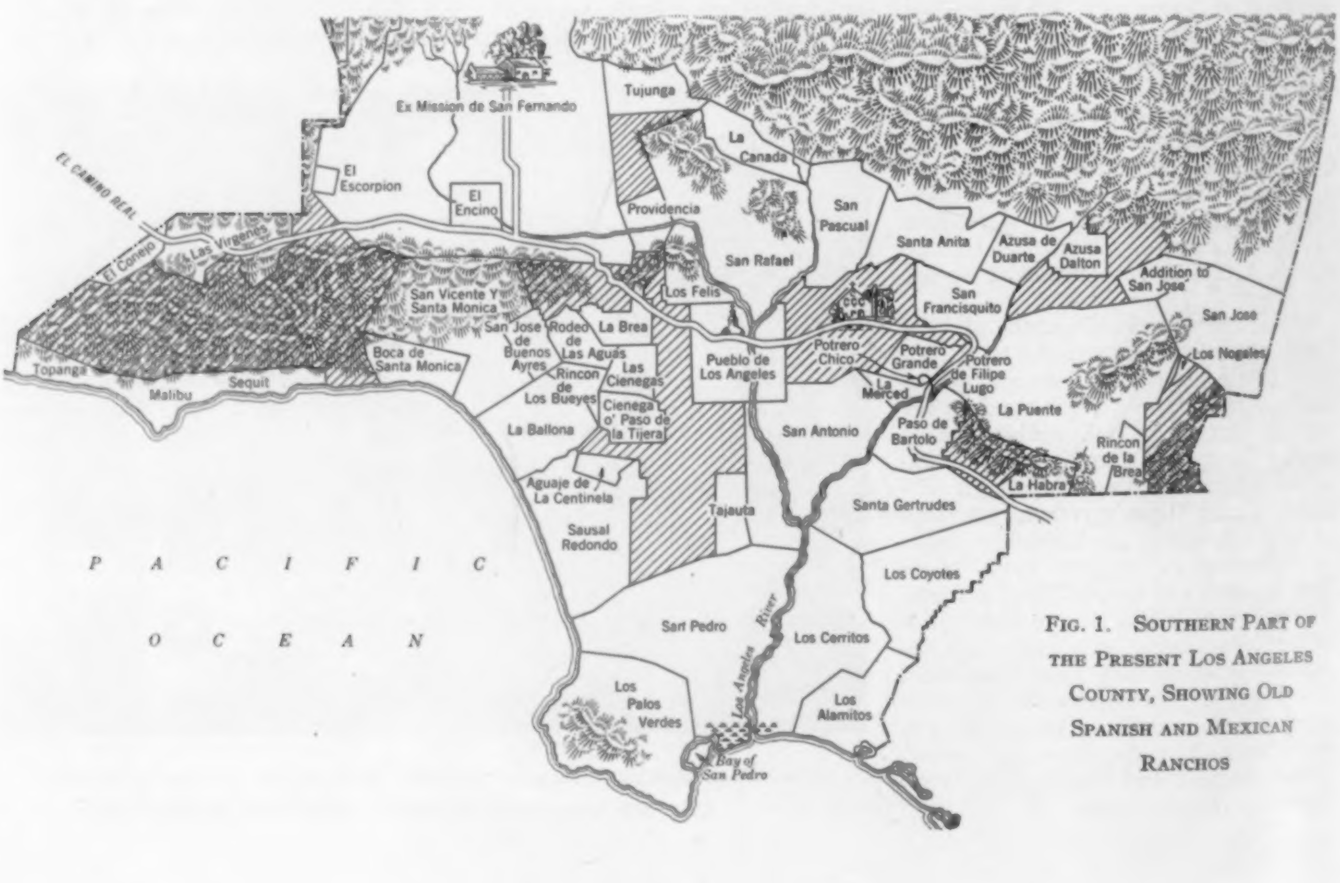


FIG. 1. SOUTHERN PART OF THE PRESENT LOS ANGELES COUNTY, SHOWING OLD SPANISH AND MEXICAN RANCHOS

The Spanish left the Pueblo of Los Angeles in hopeless disorder; adobes extended into the streets and zanjas or irrigation ditches meandered wherever the water might most naturally and easily flow. The whole town had grown without apparent care for the present or hope for any future. Even the plaza, laid out at the time the town was founded in 1781, as a large, rectangular parcel of land, had been shifted and encroached upon until it no longer resembled its original shape and was only half its original size. The new American Council determined to set the little town in order. A survey was promptly ordered but no one in the town could be found who felt able to make it; so the United States Government was asked to loan a government surveyor. Thus Lieut. E. O. C. Ord and his assistant, William R. Hutton, were sent to Los Angeles.

From their work we have the first of two very famous surveys of downtown Los Angeles, the Ord survey. The agreement between the city and Lieutenant Ord provided that he should plat the north and south streets to a width of 75 ft, but he found it easier to make the streets an even number of feet, so he made them 80 ft wide. By that slight change the city retained the ownership of land now worth millions of dollars. The agreement also provided that sandstone monuments should be placed at the corners of the lots and blocks, but owing to complete depletion of its funds, the city was unable to supply the stones and they were never set. Wooden stakes, however, were placed, but as time went on the citizens tied their animals to these stakes and soon all trace of them disappeared.

When the survey was completed, Lieutenant Ord was offered any ten building sites within the survey, each building site with 120 ft of frontage, 1,200 ft in all, and in addition 160 acres of pueblo lands outside his survey, in lieu of the $3,000 which it had been agreed he should be paid. Ord chose the $3,000.

To make the land in Ord's survey salable and usable, the city needed a new irrigation ditch, and so employed O. W. Childs to dig it. When he finished, he presented

Rancho La Brea, Which Included the Wilshire Residential District of Los Angeles

Its Asphalt Pits Have Preserved Skeletons of Prehistoric Animals

his bill to the city, which was again this famous sum of $3,000. However, the city was still in the same condition; there was no money. It settled Mr. Childs' bill by deeding to him a large parcel of city land, comprising most of the downtown district of present-day Los Angeles. No doubt he was somewhat put out, but he lived to have this same land make him amazingly wealthy, and his widow, living in Los Angeles, still owns part of the property.

A SECOND SURVEY UNDERTAKEN

To survey the outlying acreage beyond the limits of the Ord survey, Captain Henry Hancock was employed.

Santa Fé Springs, Which Owes Its Boom to the Magic Touch of Oil

It Was Originally Part of the Rancho Santa Gertrudes

His work constituted the second survey of Los Angeles. The city did not agree to pay him in cash—it had had too much trouble with the Ord contract—so it entered into an agreement that he should receive one out of every eight of the farm lots platted. Captain Hancock had been all over the acreage, of course, so he picked out the best, which was natural.

Meantime, the ranches surrounding the city and extending throughout all the area of California had remained idle. Owing to the vagueness of many of the Spanish and Mexican land grants, it was impossible to tell on their faces which were valid and which were fraudulent, and so a land commission was set up by Congress, which had had the experience of years of trouble with the French grants in Louisiana and the Spanish grants in Florida. This commission came to California, determined the true boundaries of the grants, caused new surveys to be made, and on confirmation of titles, issued patents.

ODD BASES FOR TRANSFER OF TITLE

Some of the considerations for the transfer of the land grants, adequate at that time, are now fantastic. The Rancho Aguaje de la Centinella, on which Inglewood has been built, was exchanged for a small adobe in the Pueblo of Los Angeles, where its owner could live an easier existence. But in the eyes of these early traders, the ranch was worth less than the pueblo adobe, and the ranch owner was called upon to throw in two barrels of *aguardiente* (brandy). The Topango Malibu Sequit, extending for twenty miles along the shore line above Santa Monica, was traded in settlement of a $200 grocery and wine bill.

At Pomona, old Ignacio Palomares of Rancho San Jose gave a part of his ranch away, the only consideration being that he might be protected on that side from the raids of Indians. In another case he gave away a parcel of land stipulating only that the adobe, when built, would contain a chapel where the priests might

stop and rest as they passed along El Camino Real. When, in still another case, he gave away 1,500 varas of land to one Juan N. Alvarado, the greedy Alvarado was not satisfied with the land alone and demanded cattle. So Palomares added 500 head of large cattle. But even this was not enough, so he added "and all the small head which might be found on the land." This pleased Alvarado but the title did not, so he compelled Palomares to ride to the pueblo, go before the constitutional judge, swear that he owned the land by virtue of his Mexican land grant, that he had not parted with the title to it or made donation to any other person, that he made free grant of the property, and that he warranted the title and would at his own expense settle any litigation in which the land might become involved. This done, the judge gave Alvarado a decree of ownership.

Colonization started immediately after American occupation. The first was a Mormon colony, led by Amasa M. Lyman. It purchased for $2 an acre the ancient estate of the Lugos, the Rancho San Bernardino, and platted the town of San Bernardino. Other colonies were Riverside and Ontario.

The Rancho San Pascual, on which Pasadena has been built, lay undeveloped until 1872. At that time the western part was owned by John S. Griffin, a Southerner by birth, who felt very bitter over the outcome of the Civil War. Nevertheless, when leaders of a colony from Indiana came out, he negotiated with them for the purchase of his ranch, and a deal was finally made. Dr. Griffin then rode to the little town of Los Angeles and with a great deal of spirit announced to his friends, "At last, I've got even with those Yankees; I have sold them my ranch for six dollars an acre."

COMES THE INEVITABLE LAND BOOM

After the railroads were built, when the sudden increase in population and prosperity caused land prices to soar, great subdivisions were hurriedly opened up and sold out. Many failed to show ties to adjacent subdivisions; nearly all failed to show street centers. It was a common error to label two blocks with the same number, and the purchaser could not tell which he was buying. The County Recorder, instead of checking these and encouraging the careful preparation and filing of subdivision maps, seized the golden opportunity to increase the revenue to his office by fixing a premium of ten cents for each and every line shown on the map, and an additional charge for a lot number. The result was that the more a subdivider could leave off the map, the better off he was. Maps were filed with the first and the last lots numbered and the rest left to the imagination.

The frenzy of that land boom of 1886 and 1888 extended over into Lower California. As far as 170 miles below San Diego there is a subdivision cut up as a town site. In some cases dummy railroads were built and promptly torn up when the lots were sold. Some sites had no water and some had too much. The Santa Fe Railroad itself went into the town lot business, bought up the town site of Fulton Wells, renamed it Santa Fe Springs, planned a large hotel, and cut the large lots into small ones. For a while it did an excellent business selling lots for from $200 to $500 each. After the boom broke, the lots were not worth the cost of recording the deeds. Many of the deeds to Santa Fe Springs were not recorded until nearly forty years later, when oil was discovered and they mysteriously reappeared and were placed on record.

Many of the town sites in California, cities now, had their origin in the boom. Others are still waiting for their day. In San Luis Obispo County, two 1,000-acre subdivisions were platted, the towns of El Moro and Grover; today, after 45 years or more, there is not a house in either one. At Coronado Beach, the greatest of the boom subdivisions, the original Coronda Beach Company invested one million dollars in its subdivision, built a large hotel, made three million dollars, reinvested this sum, and lost it all. Since the boom and its collapse, Los Angeles and Southern California have grown along safer and saner lines.

Physiography of the Los Angeles Area

By A. L. Sonderegger

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In presenting a picture of the Los Angeles metropolitan area, it is important to realize that the fundamental factors in the remarkable development which this country has experienced are geological and physiographical. The Los Angeles metropolitan area is here defined as the complex lowland within the confines of Los Angeles and Orange counties, extending from the Sierra Madre, or "Mother Mountains," to the Pacific Ocean. Beyond the Sierra Madre lies the plateau of the Mojave Desert. A general topographic map of this territory is presented in Fig. 1.

San Antonio, Highest Peak in Sierra Madre Rises 10,800 Ft Above Sea Level

The coast line of Southern California runs in general from northwest to southeast. This same direction is followed not only by the mountain range, but also by the intermediate range and the coastal chain of hills. These hills and mountain masses divide the lowland into a number of interior valleys and a broad expanse of coastal plain.

In its broad features, the topography of this area is the result of crustal changes which began toward the end of the Tertiary period as a differential movement of mountain making and valley deepening. Contemporary and later erosion is responsible for the canyons and the superficial details of the mountain slopes, and for the filling of the original basins and their leveling into broad plains by spreading of the eroded material over them. Uplifted blocks and constructional basins filled with

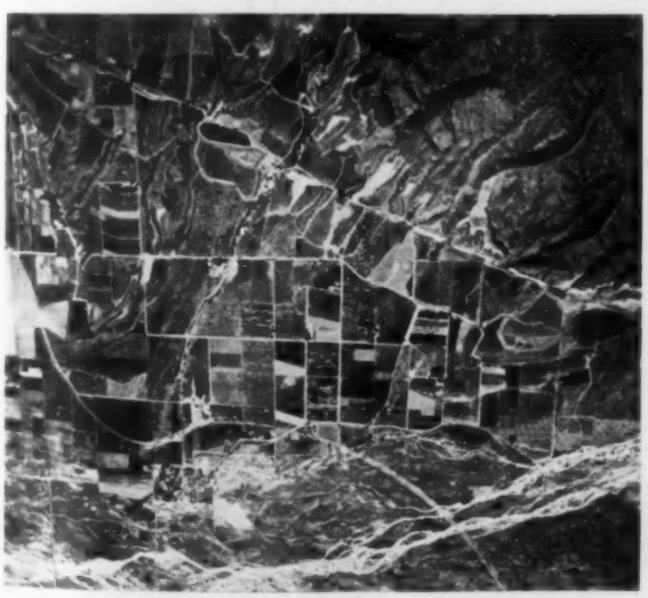
modern alluvial materials are the characteristic geological features of this region and the real foundation of its wealth. Crustal movements, such as those here discussed, normally occur along lines of weakness. It is therefore natural that there should be numerous faults, coexistent with deformation. The dominant fault of the entire area is the great fracture about 35 miles north of Los Angeles, known as the San Andreas rift, which is still active.

A feature, the effect of which is more far-reaching than might appear at first sight, is the relatively short distance within which this transition from the mountains to the sea develops. The highest peak of the Sierra in this vicinity is Mt. San Antonio, with an elevation of 10,800 ft. The distance from this peak, by way of its main drainage channel, to the 1,000-ft elevation at the mouth of the San Gabriel River canyon is about 22 miles, and from there to the sea another 30 miles. In this 50 miles may be seen the complete cycle of debris production and disposal: Erosive action in the mountain area, building-up of the flood plain and delta, and finally, destructive encroachment of the sea. This condition, combined with a semi-arid climate, confronts the engineer with phenomena which in other parts of the United States are greatly moderated in their effects by long transitional distances. The area of the lowlands and inhabitable hills shown on the map, Fig. 1, is approximately 1,500 sq miles.

CLIMATIC CONDITIONS

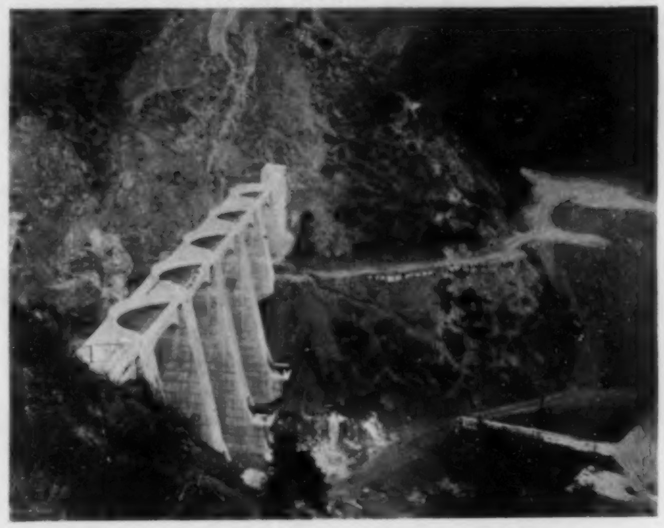
As regards temperature as well as humidity and precipitation, the sea is the regulating and moderating factor in the climate of the coastal area of Southern California. As the distance from the coast line increases, daily and seasonal fluctuations become more accentuated, attaining their extremes in the desert areas. The influence of the prevailing sea breeze results in warm winters and cool summers. At the Los Angeles station, summer temperatures vary between 49 and 109 F, with a mean of 67 F, and winter temperatures between 28 and 90 F, with a mean of 59 F.

Valley areas and coastal plain have a growing season of nine or ten months. Killing frosts may occur in December, January, and Feburary in the bottom lands, but the practically frost-free foothill belt permits the growing of semi-tropical fruits. Smudging is required a few days per season, when the temperature may drop for several hours as low as 26 F. At Los Angeles the mean relative humidity is as follows: 5 a.m., 77; 5 p.m., 61; and noon, 51.



San Andreas Fault at Mill Creek, near San Bernardino
In This Aerial View, the Great Fault Appears at Upper Left, Extending to the Mid-Point on the Right

There are only two seasons, a rainy winter, from November to April, and a dry summer, from May to October. The months of heaviest rain are December to March, inclusive. Storms are of the cyclonic type, the majority originating in the Northern Pacific, sweeping easterly and southeasterly and striking the coast at the mouth of the Columbia River. There is a marked fluctuation in rainfall from storm to storm and from year to year. The seasonal precipitation in Los Angeles averages 15 in. but has varied from 5.6 in. to 38.2 in. The average number of days on which there is a rainfall of 0.25 in. or more for the six-month season is 16. Rainfall increases generally with altitude. The maximum condensation of the moisture-laden clouds which sweep in from the Pacific occurs as they cross the mountains, so that there are only occasional winter rains in the desert areas. The coastal area experiences no summer cloudburst.



Big Dalton Dam in the Sierra Madre, 151 Ft High
Forming a 1,300 Acre-Ft Detention Reservoir

Periodic fluctuations of seasonal rainfall are also apparent, but the length of the alternating wet and dry periods is irregular. As a rule during dry periods about two years out of three are dry, and during wet periods about two years out of three are wet.

From the standpoint of water supply, seasonal, and what might be termed cyclic, regulation remains the all-important problem. However, since it is not practicable in a growing country to regulate the demand to long-period variations, an overdraft on underground storage has generally resulted.

THE SIERRA MADRE

The main mountain mass of the Sierra Madre range consists of schists, gneisses, and diorites. The strains and stresses of the uplift have had their disrupting and disintegrating effect, and in many localities the rock is blocky and shattered. To the builder of dams, this feature has proved a source of difficulties, resulting in a scarcity of suitable rock materials, poor foundations, and a relatively small number of feasible sites. However, it has this advantage, that the disintegrated and decomposed debris produces a friable sandy loam of exceptional fertility. Even the gravelly cones at the foot of the mountains have been successfully planted to citrus fruits.

The mountains rise abruptly above the plain from an elevation of 1,000 ft to 5,000 or 6,000 ft, while the back ranges reach elevations of from 8,000 to 10,000 ft. Slopes are precipitous, canyons relatively narrow, and stream gradients correspondingly steep. There is a seasonal rainfall varying from 20 in. to probably 6 ft, and averaging 36 in. Snow is a factor only in the higher altitudes and melts away in the early summer months. Slopes to elevations of 5,000 to 6,000 ft are covered with chaparral, which attains heights up to 10 ft, while in the higher altitudes, particularly on the north slopes, pine and other tree growths predominate.

It is apparent that the brush must be capable of surviving not only dry summers but also protracted periods of deficient winters rains. Such conditions have produced species that become highly inflammable in summer. Because of the vegetal cover, debris production under normal conditions is relatively small. However, if the mountain slopes have been denuded by fire, the movement of debris assumes disastrous proportions.

Absence of alluvial flats reduces seasonal and over-year storage to but a fraction of the winter flow. This fact and the "cyclic" fluctuation of rainfall, with its alternating wet and dry periods, makes regulation by storage a major problem in the water supply of Southern California. Flood peaks may reach a maximum of 400 cu ft per sec per sq mile for the San Gabriel River and over 1,000 cu ft per sec for the smaller watersheds. A number of capital floods have been recorded, and as the country becomes more and more populated, the problem of flood control becomes increasingly important.

For a realization of the difficulties which confront the flood-control engineer, it is only necessary to remember the lack of economic storage space and of suitable dam sites in the mountains, and the relatively steep gradients in the valleys and on the coastal plain. The engineers

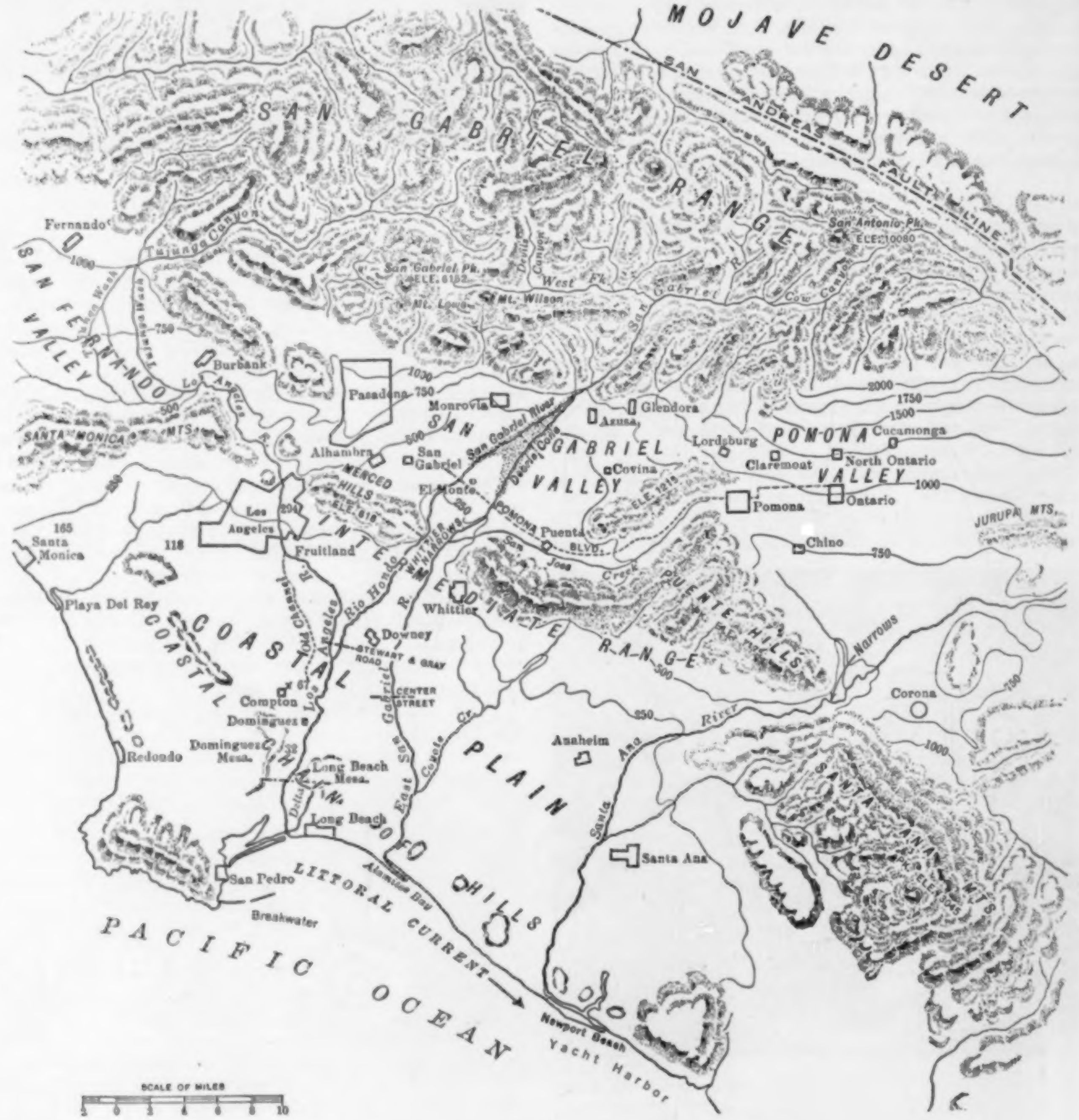


FIG. 1. TOPOGRAPHIC MAP OF SOUTHWESTERN CALIFORNIA

were also confronted by a peculiar condition resulting from the unprecedented influx of people after the War. Seventy-five per cent of the present population arrived after the last flood year, 1916, and therefore have experienced a protracted period of normal or subnormal stream flow.

Economic reasons, proximity of employment, and ignorance of climatic conditions caused large numbers of newcomers to settle on extensive tracts of lowland in which were overflow areas. This situation, combined with a demand for the conservation of flood waters, brought about a movement supported by general public pressure for the control and conservation of flood waters in the mountains. In the course of time, flood control was attempted along three distinct lines: by the construction of regulating reservoirs; by regulation of large numbers of check dams, with negligible surface storage; and by diversion of peak flows for spreading on the gravel beds of the debris cones.

Adverse physical conditions caused the failure of the first plan. Numerous reservoirs have been constructed, but their capacity is insufficient to control capital floods. Check dams, as a major flood-control measure, failed because of a basically erroneous conception of their function under prevailing conditions, and because of the type of constuction, which was not suited to withstand the floods of these mountain canyons. Spreading of flood waters over gravel areas, while eminently successful with controlled flow of minor floods, in my opinion in not feasible at peak flow because of the risk involved and the muddiness of the water, which requires an area of spreading grounds out of proportion to the benefits that might accrue from the utilization of the works once in 10 or 25 years.

There appears to remain but one remedy—the construction of large channels to carry the flood waters to the ocean by the shortest route. Even this presents its difficulties because the steepness of the flood plain induces an alternation of alluvial and erosive stream action, which successively forces the stream to flow on top of the ground and in cut, all within distances varying between 30 and 60 miles.

Moreover, these channels are subject to the cumulative effect of protracted periods without capital flood flow. The absence of a flushing discharge for 20 years or more reduces their carrying capacity to a considerable extent and thus must be taken into consideration in the planning of control works. The problem of flood control assumes a still different phase when major storms visit a burned-over area. Such areas, when denuded and exposed to heavy storms, produce abnormal quantities of debris varying in size from silt to 60-ton blocks. The runoff may then assume the form of mud flows moving at high speed as a viscous mass. In addition to the problem of controlling flashy floods, there may arise the necessity for the storage of abnormal quantities of debris. These are a few of the physical phenomena that affect the flood-control problem in this area. It is difficult to conceive of a more complex situation.

IMPROVING THE CHANNEL OF THE SAN GABRIEL
Concrete Embankment Above Whittier Narrows

LA CRESCENTA HILLS AS SEEN FROM THE HEAD OF THE SAN GABRIEL VALLEY
The Rose Bowl, Pasadena, Appears in the Foreground

INTERIOR VALLEYS

Between the Sierra and the intermediate range lie the contiguous interior valleys of San Fernando, San Gabriel, Pomona, and San Bernardino. These valleys embrace the favored residential sections and the most fertile regions of the Los Angles area, with a foothill citrus belt 2 to 5 miles in width and a hundred miles long.

Rainfall in the valley areas ranges from 6 to 36 in., with a mean of about 18 in. Temperature is largely influenced by local air drainage. Some of the bottom lands experience killing frosts in the winter. Summer temperatures may reach an extreme of 115 F, although the mean is 68 F.

The soils are predominantly sandy loams of exceptional fertility. The valley fill, being alluvial and the product of the erosion of crystalline rocks, is composed of gravels, sands, and clays. Gradation as to size of debris takes place from the foot of the mountains to the lower margin of the valleys. An excellent medium is thus provided for the absorption of flood waters and for deep penetration of rainfall. Many of the valleys have a depth of fill of 1,000 ft or more and a superficial area of over 100 sq miles. These basins provide space of gigantic proportions for the storage and long-period regulation of water supplies.

Characteristic features of the interior valleys are their constricted outlets, or "narrows," cut by the streams through the intermediate range of hills. These constrictions retard the percolating waters and have the effect of forcing them to the surface. Gradients of the terrain being steep and the valley-fill materials coarse and of high permeability, the stream channels, as they approach the narrows, serve as effective drains for this rising water. By the ingenuity of nature, the water supplies of this semi-arid country are stored in underground reservoirs for cyclic regulation. Remaining fresh for indefinite periods, they are finally brought to the surface by the simple means of a transverse range of hills. The inter-

mediate range, of sedimentary origin, is also an oil anticlinal and for many years past has produced very substantial quantities of petroleum.

THE COASTAL PLAIN

The coastal plain slopes from an elevation of about 200 ft at the foot of the intermediate range to tidewater, with gradients dropping from 25 to 5 ft per mile. Roughly speaking it covers 1,000 sq miles of valley and inhabitable

EXTENDING SAN PEDRO BREAKWATER, LOS ANGELES HARBOR
A Rubble Mound Being Constructed on the Alluvial Bottom

hills, and is watered by the Los Angles, San Gabriel, and Santa Ana rivers. A fertile, friable sandy loam soil prevails within the meanders of the rivers, while clayey soils are found in the vicinity of the shale outcrop of the hills. The plain is traversed by a range of low hills, a sedimentary oil anticlinal, roughly paralleling the coast. The maximum temperature for the summer months averages 78 F with a high of 107 F; the average minimum temperature for the winter months is 44 F, with 21 F as an extreme low. The mean seasonal rainfall is about 12 in.

Beneath the coastal plain, deposits of fresh water gravels, sands, and clays are found to depths of 1,000 ft or more below sea level. Extensive clay blankets indicate that at times the plain was submerged. As the percolating waters approach the barrier hills, these blankets and the effect of the coastal anticlinal induce artesian pressure. Because of the relative fineness of the fill materials and because of the flatter gradients and shallow stream beds, the line of least resistance for the rising ground water is to the surface and not into stream channels. The natural disposal of the water is therefore by evapotranspiration from moist areas. However, the draft and, in some areas, overdraft on underground storage by artesian and pumped wells has lowered the water table to such an extent that drainage no longer presents a problem. By the drilling of wells, independent water supplies can be developed and large numbers of small ranches have thus prospered under individual ownership. The slopes of the intermediate range, from Los Angles to Santa Ana, are frost-free and have become a region of highly developed citrus culture.

THE COAST AND ITS DEVELOPMENT

The west coast of the Los Angeles area is precipitous and, barring piers built into the open roadstead and minor basins protected by breakwaters, is not adapted to port development. Suitable geological and topographical conditions for the construction of inland harbors are found along the southern coast, at the estuaries of the three rivers, from San Pedro to Newport Beach. The deltas, with their deep silt deposits, offer excellent opportunity for the dredging of channels and basins along a shore frontage of about 20 miles.

Thus, the ports of Los Angeles and Long Beach have developed as land-locked, artificial harbors, capable of accommodating ships of any size up to 40-ft draft and protected from the silt load of the Los Angeles and San Gabriel Rivers by a confined flood-control channel. Tidal fluctuations are an unimportant element in port design, construction, and maintenance. Storms along this coast may be termed decidedly mild as compared with those farther north or on the Atlantic seaboard.

Between San Pedro and Newport Harbor, the bottom of the sea is alluvial and of a formation which affords not only excellent anchorage but also a suitable foundation for breakwater construction. A breakwater 11,000 ft long at the mouth of the Los Angeles harbor, constructed over 30 years ago as a rubble mound, has successfully weathered all storms and has furnished proof that offshore structures afford protection for anchorage as well as for slips and docks. This old "San Pedro Breakwater" is now being extended in the direction of Long Beach. The opportunity for further extension is unlimited; hence anchorage and dockage may be provided as necessity requires. There is unlimited opportunity along the south coast of the Los Angeles area for the construction of commercial and naval basins.

Geological and physiographical features of a permanent character have favored the agricultural and industrial development of Southern California. These factors have been assisted by favorable climatic conditions and, last but not least, by the unparalleled concerted effort of an aggressive people taking advantage of natural resources and commercial opportunities.

Engineering Contributions to California

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THERE have been two periods of rapid growth in California, the one following the discovery of gold in the mountains of the central and northern parts of the state in 1848, and the other following the completion of the Santa Fé Railroad system in Southern California in 1886 and 1887. In each instance the engineer was called upon to invent equipment and methods to solve the local problems that presented themselves.

In central California there is a magnificent natural harbor into which navigable streams flow, with a hinterland containing large supplies of timber, with enormous tributary agricultural areas, and with the gold-producing mother lode in the background. These resources, coupled with the courage and energy of the people who have settled in the region, have resulted in an amazing development.

The striking characteristic of Southern California is the growth that has occurred in the last fifty years with only limited natural resources. There are no large rivers, no natural harbor except San Diego, no forests, no great expanses of agricultural back country save unreclaimed deserts, no nearby large water-power opportunities, and no extended local market for manufactured commodities. Los Angeles is a city situated in a remote corner of an extensive desert area. The large oil deposits were not extensively developed until about 1902. Southern California with these handicaps was peopled with a vigorous race which has provided the human energy from which its growth has resulted. The development of the state has been based largely on the ability of its engineers, backed by the organized cooperation of its civic leaders.

Gold in California was first discovered in the auriferous gravels. The mining process consisted of washing these deposits, and involved hydraulics rather than metallurgy. There resulted numerous inventions developed by a remarkable group of engineers, including the late Hamilton Smith, M. Am. Soc. C.E., Ross E. Brown, Bowie, and others whose services were subsequently sought for throughout the world. They were of the "practical" type rather than men of technical training, although a few came from the German universities. As the deep veins of the mother lode were explored, technically trained mining engineers such as John Hays Hammond and Herbert Hoover, Hon. M. Am. Soc. C.E., became prominent.

Hydraulic mining required the storage of flood water, and its conveyance in various types of conduits to hydraulic giants, which were used to tear down deposits of gravels.

ROCK-FILL AND HYDRAULIC-FILL DAMS

One of the types of dams for the impounding of flood water adopted by the early mining engineers was a

El Capitán Dam, Recently Completed for the City of San Diego
A Hydraulic-Fill Dam 240 Ft High

combination of crib work and rock fill with a plank face. The English Dam, having a height of 131 ft, was built in 1856. The Bowman is the outstanding early rock-fill dam in California. It was designed and built in 1872 by Hamilton Smith for the North Bloomfield Mining Company, and served continuously up to 1927, when it was rebuilt and its height increased to 165 ft by the Nevada Irrigation District.

The Salt Springs Dam of the Pacific Gas and Electric Company on the Mokelumne River represents the culmination of rock-fill dam construction in California. It is 330 ft high and has a concrete face.

Small hydraulic-fill dams were first built in the early days by hydraulic giants and sluicing. The first large-scale application of this method was by A. Chabot who, in 1868, built the Temescal Dam, 105 ft high, for the

Hodges Reservoir Multiple-Arch Dam
On the San Dieguito River, California

City of Oakland by a combination of rolled fill and sluicing. The late J. M. Howells, M. Am. Soc. C.E., built a modern type of hydraulic dam at Tyler, Tex., in 1894. He subsequently came to California and in 1895 constructed the La Mesa Dam in San Diego County. This was followed by many others of this character, as described in detail in the book on reservoirs by the late James D. Schuyler, M. Am. Soc. C.E. H. N. Savage, M. Am. Soc. C.E., recently completed for the City of San Diego at El Capitán, a hydraulic-fill dam that is 240 ft in height above the foundation and contains 2,702,000 cu yd.

In the past these dams represented a cheaper type of construction than the rolled-fill earthen dam, but the advances in modern equipment for moving earth have of late largely changed the relative costs in most localities.

RIVETED AND WOOD-STAVE PIPE

In the early part of this hydraulic mining period, when freight came around Cape Horn, construction materials were expensive. The earliest pipe used to generate heads for washing the gold gravels was of canvas with a wooden nozzle. Riveted iron pipe with slip joints was a California development of 1853. The plates were shipped flat, punched along their longitudinal edges for rivets, rolled into form by San Francisco mills, and nested for shipment to the miners. The plates were riveted where the pipe was to be installed and were put together with a slip joint called a "stove-pipe joint." Even under heads of from 400 to 500 ft, riveted pipe was satisfactory. Herman Schussler, M. Am. Soc. C.E., further developed the riveted wrought-iron pipe, using it for the supply lines to San Francisco, and in 1870 for the Cherokee 30-in. line, 14,000 ft long, across a depression under a head of 887 ft.

Wood-stave pipe has also been important to the development of California, where it is suitable for use because of economy and the wealth of good timber for staves. The late D. C. Henny, M. Am. Soc. C.E., and the late Arthur L. Adams, M. Am. Soc. C.E., were prime movers in this work, which meant much to other Western states as well.

IMPULSE WATER WHEELS

Crude impulse water wheels, which had been used in European countries for several hundred years, were improved by the early engineers in their mining operations.

These wheels, known as "hurdy-gurdies," were first built by the Argonauts between 1850 and 1860. They consisted of wooden planks fastened together with coarse teeth like a circular saw in the rim. The open ends of the tooth channels were flanged, forming pockets or cups in the rim of the wheel on to which the water was projected from a nozzle. Buckets that reversed the jet were first used at the Guin mine in 1886.

Professor Hesse of the University of California designed the split bucket to be fastened to the perimeter of the wheel. He was a young scientist who escaped from Germany under the back seat of a coach during the German revolution of 1848. As the result of numerous tests, Messrs. Pelton and Doble later improved the efficiency of the wheels which they manufactured in San Francisco.

FLOOD SPREADING ON CUCAMONGA CREEK, CALIFORNIA
The First Spreading for Conservation Was Done on the Absorbent Debris Cone of This Creek

RAILROAD CONSTRUCTION

At the meeting of the Society held in Sacramento in 1930, a monument to the memory of Theodore Dehone Judah, M. Am. Soc. C.E., was unveiled in the station grounds of the Southern Pacific Company. It consists of a large granite boulder from the Sierras with appropriate inscriptions to the memory of this engineer. In 1854 Mr. Judah, then a young man of but 28 years, came to California as chief engineer of a small railroad from Sacramento to Folsom. Becoming interested in a proposal to construct a railroad eastward from Sacramento over the Sierra Nevada, he prevailed on Stanford, Huntington, Hopkins, and Crocker, who were at that time engaged in commercial pursuits in Sacramento, to finance the cost of the necessary surveys. After the feasibility of the project had been demonstrated, the Central Pacific Railroad Company of California was organized in 1861. Judah was also instrumental in the passage by Congress of the Pacific Railroad Bill, which was signed by President Lincoln in 1862. This line connected California with the eastern parts of the United States by rail, and was an important national as well as local achievement.

In giving brief consideration to transportation, the name of the late William Hood, M. Am. Soc. C.E., should not be omitted. He built the Southern Pacific system from Portland to New Orleans and was instrumental in maintaining rainfall and temperature observations at the stations of this system as well as readings of river gage heights at railroad bridge crossings on most of the important rivers.

HYDRO-ELECTRIC DEVELOPMENT

While the experimental transmission of electric energy for short distances was first accomplished in Vienna, the records available indicate that among the earliest commercial transmission of hydro-electric energy was from Oregon City to Portland, Ore., in 1889. This was a single-phase system 13 miles in length. An early plant of the three-phase type, perhaps the first in America, was built in 1893 on Mill Creek in San Bernardino County by O. H. Ensign, for the predecessors of the Southern California Edison Company.

John Hays Hammond, the eminent mining engineer, was a pioneer in hydro-electric development. He built the Mt. Whitney Power Plant on the Kaweah River largely at his personal expense in 1898. Today hydro-electric plants have been constructed on practically every major stream in the state, many of large capacity. Fowler in 1923 described all the California hydro-electric installations in the U. S. Geological Survey Water Supply Paper 493.

The power plant being built at the Boulder Dam by the U. S. Reclamation Service will serve Southern California, Arizona, and Southern Nevada, with a present capacity of 515,000 hp. Its ultimate capacity is to be three times this amount. The transmission line to Los Angeles will be 280 miles long.

TRACTORS, DREDGES, AND MISCELLANEOUS DEVELOPMENTS

An important advance in industry and military equipment has been the caterpillar tractor. This was invented by Benjamin Holt of Stockton in 1900, for the purpose of plowing the peat swamps of the lower Sacramento Valley. It was first used extensively for engineering purposes during the construction of the Owens Valley Aqueduct in 1908, but has now become an essential tool on heavy construction work. Tractors were used for the draft of heavy guns during the World War.

The hydraulic dredge is a California product which has come into general use. Its invention was claimed by A. B. Bowers, who carried on extended litigation in many courts for infringements of his patent rights. He is said to have spent half his working life in this litigation. Another engineer identified with the invention was Col. A. W. Von Schmidt, who came to California in 1849.

SPREADING WORKS IN SAN FERNANDO VALLEY FOR LOS ANGELES AQUEDUCT
The Practice of Spreading Water for Storage Is Being Widely Followed in Southern California

The rapid rebuilding of San Francisco following the fire and earthquake of 1906 is probably as great an achievement as has been accomplished by the engineers

and architects of America. The spirit of the engineers of central California is shown today in the building of the bay bridges and in the project for storing flood waters on the Sacramento River and distributing them throughout the central valley of the state.

LOS ANGELES HARBOR

The present-day Los Angeles–Long Beach harbor originally was a series of shallow lagoons and tidal mud flats on which the San Gabriel and Los Angeles rivers discharged their debris. The original depth of water at low tide on the entrance bar was but $2^1/_2$ ft. Before the harbor could be successfully maintained, the floods of the Los Angeles and San Gabriel rivers had to be diverted to a new outlet. This was done by the joint efforts of the Army Engineers and the Los Angeles County Flood Control District. Channels, turning basins, and slips have been excavated and the dredged material deposited on the intervening flats to raise them to proper elevations for docks and warehouses. As a result there is what has been called a "tailor-made" harbor.

As a protection to the entrance of the inner harbor, a breakwater two miles in length was completed in 1912. It is now being extended a mile further, and will ultimately be 4.5 miles long. At present the harbor is one of the best on the Pacific Coast. With the completion of the breakwater, it will be one of unusual merit.

IRRIGATION DEVELOPMENTS

The climate of California, with the dry months occurring during the summer growing season, makes irrigation necessary to agriculture. The padres brought this art with them when they established their missions. As the value of this form of agriculture became recognized the demand for greater hydraulic works has grown until the summer flow of practically every stream in the state has been diverted, except in the far northwest. More and larger reservoirs have been provided until now 584 dams are listed within the commonwealth. The importance of irrigation was recognized in 1880 by the appointment of the late William Hammond Hall, M. Am. Soc. C.E., as state engineer, with Grunsky, Schuyler, and Manson as assistants. Hall began the gaging of streams and the collection of information about underground water supplies in the south. After an interruption of this work from 1885 to 1892, it has been continued and expanded by the U. S. Geological Survey. Today 5,452,000 acres have been reclaimed by irrigation in California, practically all by private capital and local districts. These California projects are distinctly an accomplishment of the engineering profession.

Excluding the Owens Valley Aqueduct, 90 per cent of the water supply for the south coastal basin, which includes the counties of Orange, Los Angeles, Riverside, and San Bernardino (exclusive of Ventura) comes from wells. The streams, which are torrential during the winter rainy season and almost dry in summer, have filled the valleys and plains in places to depths of over 1,000 ft with sands and gravels saturated with water. The scarcity of surface water has led to the sinking of many wells in these valleys.

This condition has resulted in the invention of what is called the "California type" of well consisting of steel pipe, driven together in overlapping double lengths of 2 ft. It is forced into the ground by hydraulic jacks and cleaned out with sand buckets. Small wells of this type were sunk as early as 1872 near Anaheim. These wells and the methods used in sinking them are described in detail by Slichter in U. S. Geological Survey Water Supply Paper 140.

Concurrently with the development of this California type of deep well, a pump was necessary to operate in such a confined space and with wide fluctuations of water levels. There resulted the deep-well pump, which is suspended in the well to any desired depth and operated with an electric motor directly connected to its shaft. As much as 10 cu ft per sec are lifted 400 ft or more by these plants. The installation is cheap and flexible as compared to former standards and is a distinct engineering and manufacturing advance.

Morris Dam and Reservoir
In San Gabriel Canyon, California

Daniel W. Mead, M. Am. Soc. C.E., and Byron Jackson of San Francisco designed in 1902 a pump and inner cover pipe for the rotating shafting. This basic design still persists. A previous deep-well turbine manufactured in Paris in 1883 had proved unsatisfactory.

Coincident with the development of this type of pumping plant, and as an essential part of it, California hydroelectric engineers have pioneered in long-distance power transmission both in central and southern California.

FLOOD CONTROL AND SPREADING

In the early days about 1,000,000 acres of land were subject to overflow from the Sacramento and San Joaquin rivers and thereby made swamp. The United States gave these lands to the state under condition that they be reclaimed. This required hundreds of miles of levees. In this connection the clamshell dredge was developed to a high state of perfection, superseding the wheelbarrows and Chinese labor with which the work was started.

In order to safely reclaim these lands, some means had to be devised to care for the larger floods. In 1893–1894, the late C. E. Grunsky, Past-President Am. Soc. C.E., and Marsden Manson planned a comprehensive by-pass system for this purpose. With some modifications this system has been carried practically to completion.

A novel feature in modern water supply engineering in Southern California consists of the diversion of flood flows by canals on to "spreading basins" situated on the apex of absorbent debris cones. By this means water is put underground at low cost and conserved for later use by wells located at lower elevations. Storage underground is not only cheaper than in surface reservoirs, but water so impounded is free from losses attributable to evaporation.

OIL FIELD AT SIGNAL HILL, CALIF.
Looking Southeast Toward the City of Long Beach

SINGLE-ARCH AND MULTIPLE-ARCH DAMS

As far as I know, the Zola Dam, built in France about the year 1843, was the first thin-section dam relying for its stability on the arch principle. This type was not at first generally accepted by the engineering profession as safe, and it remained for California engineers to courageously endorse this principle.

In 1883–1884, F. E. Brown of Redlands, Calif., engineer for the Bear Valley Irrigation Company, built the original Bear Valley Dam on the Santa Ana River, with a thin section relying on the arch principle. In 1898 the Upper Otay Dam was built in San Diego County which is of a still frailer section. These dams accomplished the purpose for which they were designed, and, in fact, I know of no thin-arch dam that has failed. The study of the principles involved in the design of thin-arch dams culminated in the building and testing of the Stevenson Creek test dam of very thin section in central California in 1926, described in the PROCEEDINGS of the Society for May 1928, Part 3.

As a competitor in economy to the thin-section single-arch dam, J. S. Eastwood, of Fresno, Calif., designed the multiple-arch dam, consisting of a series of arches of short radii resting on buttresses inclined upstream. The first of these dams in California was built in 1908 at Hume Lake, Fresno County, California, for the Hume Lumber Company. Its construction has been followed by that of numerous others. The first multiple-arch dam of which I have knowledge was built by French engineers at Hyderabad in India about 1811. This was of masonry, the arches being vertically supported by buttresses. It is not known whether Mr. Eastwood was aware of this design.

OIL DEVELOPMENTS

Next to agriculture the greatest natural resource of Southern California is the oil that has been found during the past generation. According to the California State Division of Mines, up to 1933, 4,064,684,473 bbl of oil have been produced, having an estimated value of $4,074,491,151. As the shallower oil sands have become exhausted, subsequent deeper drilling has penetrated new deposits of greater value until wells are now drilled to depths of 10,000 ft. Equipment has been improved to some extent locally, to make this possible. A branch of the profession known as petroleum engineering has resulted.

LOS ANGELES WATER SUPPLY DEVELOPMENTS

The original water supply obtained by gravity from the Los Angeles River was first used for the irrigation of the Spanish pueblo lands, which embraced four square Spanish leagues, equal to 28.01 sq miles. As the city grew, the irrigation supply was used for domestic purposes. A study of the underground water supplies of this region, begun by the U. S. Geological Survey in 1900, indicated that all the local water, surface and underground, was required for the outlying territory, and that it was beginning to be overdrawn. The Board of Water Commissioners of the city as well as its chief engineer, the late William Mulholland, M. Am. Soc. C.E., realized that if the city invaded the local underground sources, the communities commercially tributary would be injured. It was accordingly decided to bring in as large a new supply as was possible and to obtain it from a region where the minimum injury would be caused by the exportation of its water. The city was the only available political subdivision financially able to pay for such a project.

The late Fred Eaton, M. Am. Soc. C.E., former city engineer and mayor, about 1904 conceived the possibility of conveying the waters of the Owens River to the city and of generating power along the line of the proposed conduit. The rights to this water had been acquired by the city in 1902. Mr. Eaton brought to the attention of Mr. Mulholland his views on the Owens River supply. No adequate maps were available upon which to base a judgment as to the feasibility of this bold project, but Eaton and Mulholland went over the intervening 259 miles between the Owens River and Los Angeles with aneroid barometers and reached a preliminary conclusion that the project was feasible. The work was completed in 1912 by day labor, within the estimated cost and time. On this work Mr. Mulholland was chief engineer and I was principal assistant. The length of the aqueduct to the head of distribution is 238 miles. When constructed, the project was a record in aqueduct building.

CALIFORNIA INSTITUTE OF TECHNOLOGY

A review of the engineering achievements in California would be incomplete without reference to the California Institute of Technology. The predecessor of

this institution was founded by A. G. Troop in 1891. It was expanded, reorganized, and endowed by Arthur H. Fleming, a Canadian-born lumberman, about 1910. It was by Mr. Fleming, in collaboration with the astronomer, George E. Hale, then in charge of the Carnegie Observatory on Mt. Wilson, that the decision was made to devote the institution to study and research work in pure and applied science. The staff and laboratories of the Institute are often placed at the disposal of engineers in aiding in the solution of difficult problems. Prof. Royal W. Sorensen and other Institute engineers in 1924 aided the Southern California Edison Company in the construction of its then unprecedented 220,000-v transmission line, 241 miles long. In recognition of this assistance the company built a high-tension laboratory for the Institute.

An aeronautical laboratory has been built by the Daniel Guggenheim Fund for the promotion of flying. This contains a wind tunnel capable of developing wind velocities of 200 miles per hr. It was here that the models for the Douglas air liner were tested. As a result the speed of this ship has been increased from 190 to 220 miles per hr.

Supplementing the work with aeroplanes, the study of meteorology has been advanced at the Institute to such an extent in the forecast of weather conditions that all major air lines in the United States are now employing its methods.

The laboratories of the Institute are aiding the design of special pumps for the lifting of the water of the Colorado River Aqueduct 1,600 ft over the divide of the Coast Range. Valuable work is under way in the study of earthquake-resistant buildings. The 200-in. reflecting lens for Palomar Observatory in San Diego County has been cast and will soon be ground in the laboratory of the Institute.

BOULDER DAM

The division of water of the Colorado was and is of vital importance to two states in Mexico and seven in the United States. As priority of beneficial use initiates the priority of water rights, great projects for diversion to California, such as the then-proposed Metropolitan Aqueduct and the All-American Canal on the lower river, at first engendered opposition from other states.

This situation caused protracted delays and was extremely difficult to adjust. The Santa Fé conference of delegates, called from all commonwealths of the United States involved by Herbert Hoover, in November 1922, resulted in the agreement known as the Colorado River Compact, which provides that in any consecutive 10-year period 75,000,000 acre-ft of water must be permitted by the states situated north of the Grand Canyon of the Colorado to pass down to the states situated south of the Grand Canyon.

I wish to acknowledge my indebtedness to the late Otto von Geldern, M. Am. Soc. C.E., for information obtained from his articles entitled "Reminiscences of the Pioneer Engineers of California," published in *Western Construction News* in 1929 and for other data obtained from an article by J. D. Galloway, M. Am. Soc. C.E., presented before the International Engineering Congress in San Francisco in 1915. F. C. Herrmann, M. Am. Soc. C.E., consulting engineer of San Francisco, has also materially assisted by commenting on this paper and furnishing certain corrections and additions.

Engineering Outlook for Southern California

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Southern California has been distinguished by many outstanding engineering projects. While the projects of the future may not be as spectacular from the construction standpoint as those now under way, nevertheless the ingenuity of the engineer will be taxed in correlating the overlapping functions of independent agencies and in solving many of the hitherto neglected problems of transportation, rapid transit, and aviation.

The region usually referred to as "Southern California" extends from the Tehachapi Mountains to the Mexican border. It includes an area of about 45,000 miles—almost as large as the state of Pennsylvania. The most important projects now under way in this section include the Mono Basin extension of the Owens Valley Aqueduct for Los Angeles, the Boulder Dam, the power lines from it, the Metropolitan Aqueduct, and the All-American Canal.

MONO BASIN PROJECT

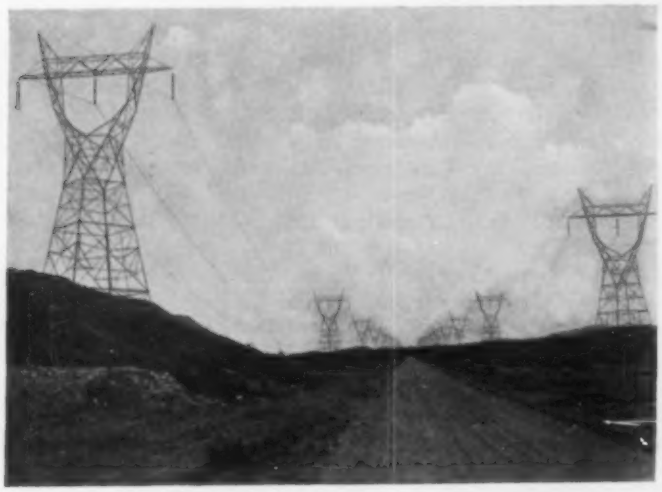
The work of extending the Owens Valley Aqueduct system into Mono Basin, over 340 miles north of the City of Los Angeles, has just been started under force account by the Los Angeles Bureau of Water Works and Supply. This project contemplates intercepting the major streams now wasting into the alkali Mono Lake, increasing storage facilities at Grant Lake, constructing an 11 $^1/_4$-mile tunnel through the Mono craters into the Owens Valley watershed, and developing a 163,000 acre-ft storage reservoir at Long Valley. The total estimated cost of the project is $9,300,000. This is a significant project because it will permit the Owens Valley aqueduct to be operated continuously at its full capacity of 480 cu ft per sec. Fifteen per cent of the tunnel is excavated, and the project is scheduled for completion in 1937.

BOULDER DAM PROJECT

Boulder Dam will form a great lake over 115 miles in length, with 550 miles of shore line, and will create a desert resort area of great importance. The reservoir will so regulate the flow of the Colorado River that continuous demands for domestic and irrigation water in parts of Southern California, Arizona, and Mexico can be met, cheap power developed, additional lands put under cultivation, and the flood menace of the Imperial Valley and Mexico eliminated. The installed horsepower at Boulder Dam will be 1,835,000, which is four times greater than that developed on the American side of the Niagara River. A safe, continuous output of over one million horsepower is assured. The government has agreed to sell power from falling water at the dam for 1.63 mills per kwhr, a rate which will stimulate Southern Californian industries.

An important part of the Boulder Dam project is the All-American Canal, carrying 15,000 cu ft per sec, which

will be extended to Coachella Valley, now without any appreciable supply (Fig. 1). The main canal is to be 200 ft wide at the water surface and 22 ft deep, and will replace the canal of the Imperial Valley which now flows for a long distance through Mexico. The length of the All-American Canal from the Colorado River to Imperial Valley will be 80 miles, and to Coachella Valley 130 miles.



BOULDER CANYON–LOS ANGELES TRANSMISSION LINE
A View of the 270-Mile Line near Silver Lake Camp

The total area of 416,000 acres now irrigated in Imperial and Coachella valleys will be increased to 1,000,000 acres. The entire project is financed by the government, administered by the U. S. Reclamation Service, and is to be paid for through the revenue resulting. The total cost of $165,000,000 is divided as follows: $70,600,000 for construction of Boulder Dam, $38,200,000 for power development at the dam, $38,500,000 for the All-American Canal, and $17,700,000 for interest during the construction period.

BOULDER CANYON–LOS ANGELES TRANSMISSION LINE

The power transmission line from Boulder Dam to Los Angles, 270 miles in length, is being constructed by the Bureau of Power and Light of Los Angeles. The towers, of unique design, will carry 1,620 miles of hollow segmented copper cables 1.4 in. in diameter, with 1,000 miles of overhead ground wire for protection against electrical storms and an additional length of counterpoise wire plowed into the ground. Power will be transmitted at 275,000 v. The line will cost $22,800,000 and is scheduled for completion in 1936.

LOS ANGELES METROPOLITAN WATER DISTRICT AQUEDUCT

The Metropolitan Water District of Southern California, embracing 13 of the larger cities in Los Angeles and Orange counties, was organized in 1928. In 1931 the District voted $220,000,000 to bring Colorado River water into the metropolitan area. This project includes a diverting dam at Parker Canyon, 150 miles below Boulder Dam; a 240-mile main aqueduct to a proposed reservoir near Riverside, to be called Cajalco Reservoir; and the construction of main distributing lines to all member cities, including the farthest distant, Santa Monica on the Pacific coast.

The main part of the aqueduct will have a capacity of 1,600 cu ft per sec, and the combined pumping lift of four pumping plants en route will be 1,628 ft. As of July 1935, two-thirds of the tunnel excavation is complete and work is progressing on 52 miles of covered conduit and 63 miles of open channel. The aqueduct is scheduled to be completed in 1939.

The Los Angeles Metropolitan Water District has turned over the construction of the Parker Dam to the U. S. Reclamation Service. The dam is to be of the arch type, will impound 717,000 acre-ft and will cost $10,000,000. On account of soil conditions, the total depth of the dam will be 200 ft, although its water depth will be but 72 feet.

The District will build and operate 230 miles of transmission lines from Boulder Dam to the pumping plants along the aqueduct. The main line will carry 230,000 v and will eventually utilize 36 per cent of the power generated at Boulder Dam.

ACTIVITIES OF LOS ANGELES FLOOD CONTROL DISTRICT

Streams in the metropolitan area are dry the greater part of the year, but are subject to flashy floods which overflow channels, cut new stream beds, damage residential areas, and change mountain topography.

Geological evidence indicates that the Los Angeles River in times past may have discharged into the Pacific Ocean from Santa Monica to as far south as the Santa Ana River. The latter river may have once discharged as far north as the deep channel off the coast of Redondo. Flood control is an actual necessity, and the future program in Los Angeles County alone is estimated at $99,000,000 for dams, erosion control, conservation by spreading, and rectification of channels. Out of the $365,000,000 recently appropriated for flood control throughout the nation, it is expected that $67,000,000 will be allocated to work within the Los Angeles flood control district.

ADDITIONAL RAILROAD FACILITIES NEEDED

Railroad transportation for Los Angeles is certain to be improved. Passenger traffic will be increased by major realignments in transcontinental routes, use of air-conditioning equipment, and adoption of streamlined engines. A new, centrally located union station, serving

FIG. 1. SOUTHERN CALIFORNIA AQUEDUCT SYSTEMS AND POWER LINES

three transcontinental railroads and costing $10,000,000, is now (1935) under construction. Freight classification yards are being provided which, with a justified lowering of rates, will place Los Angeles in a favorable trade position. At present the chief transportation facilities of the city are by water.

Desirable Municipal Improvements

Recently the City of Los Angeles applied to the government under the National Industrial Recovery Act for $321,000,000 to be used toward the construction of water works, sewerage works, storm drains, highway work, and similar types of construction. Most of this work represents projects hitherto deferred, which can now be executed to advantage from the employment standpoint and would in time benefit the city. A large part of the unemployed in Los Angeles were construction workers in the boom period of the city, and only such a plan can provide relief and prevent another unbalanced period when the next construction boom takes place.

It is readily seen that projects designed to develop natural resources, promote industrial activity, and provide useful work for the unemployed will favor a great future growth in Southern California. One of the chief obstacles is lack of proper coordination of similar activities carried on by different agencies. A state of almost complete chaos exists so far as correlation of engineering activities involving water supply, sanitation, drainage, and transportation are concerned.

Usually the metropolitan area of Los Angeles is referred to as the south coastal plain. This area is occupied by four separate counties, each with an independent board of supervisors and staff. The area north of the city, but outside the south coastal plain, lies in still another county. The south coastal plain itself contains 62 separate municipalities and 63 unincorporated communities. In one of the counties outside the City of Los Angeles there are over 1,500 special districts with 22 different functions, such as water supply, sanitation, flood control, and mosquito abatement. Gross duplication, serious overlapping, and improper timing of projects exist, constituting a direct challenge to the engineering profession to find some way whereby engineering activities may be placed on an efficient basis.

The City of Los Angeles has an area of 440 sq miles. The residential development in many cases extends from Los Angeles into 38 other adjoining cities, and completely surrounds four of them. It would appear logical to have a city and county of Los Angeles extending from the Los Angeles County and Orange County boundary between the ocean and the Puente Hills, thence north to the San Gabriel range, and west to include the Santa Monica Mountains. A neutral strip, including the remaining area in the south coastal plain and parts of Ventura County, should then be placed under county control headed by a single board of supervisors. Such a reorganization might appear radical and difficult to secure, but only through the formulation of such a plan by engineers will the expected future growth of Southern California materialize.

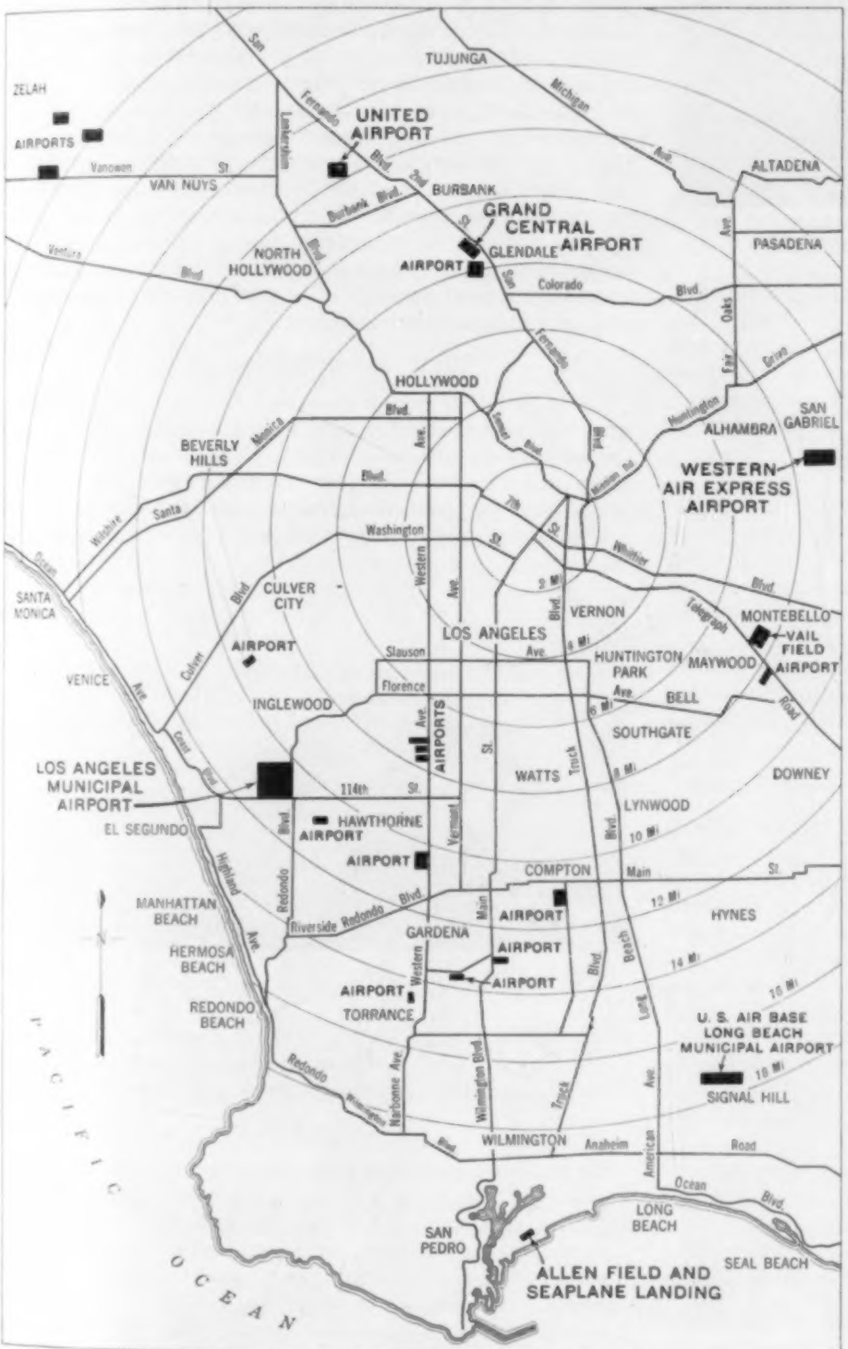


Fig. 2. Airport Service in Southern California Needs Coordination

Additional Water Supply Sources

More and more the practice of spreading water over sand and gravel areas for the purpose of increasing underground storage is being followed in Southern California. Practically all the available sites for surface reservoirs have been utilized for surface storage. Adequate local storage of course must be provided to tide over possible interruptions of the aqueduct supply. There are decided advantages in utilizing underground storage basins

because there is less evaporation loss and no trouble from algae tastes and odors. Storage over long periods of time can be made effective by pumping with relatively low lifts.

The City of Los Angeles, prior to the construction of the Owens Valley aqueduct, obtained most of its water from wells and galleries in the Los Angeles River located at various points in the lower end of the San Fernando Valley. By the construction of spreading grounds for excess winter flows of the aqueduct in this valley, by spreading flood waters impounded by the Pacoima and Tujunga flood-control dams, and by returning irrigation waters, an enormous reserve underground water supply has been created in San Fernando Valley. Wells and other equipment have already been installed whereby 100 mgd can be delivered to Los Angeles.

IMPROVEMENTS ARE UNDER WAY AT LONG BEACH HARBOR

By developing the Owens Valley aqueduct to its full carrying capacity, increasing the local underground supplies by spreading winter flows from outside sources, conserving and spreading waters from flood-control dams, importing 1,500 cu ft per sec of water from the Colorado River into the Los Angeles basin, and bringing 15,000 cu ft per sec of water into Imperial and Coachella valleys by the All-American Canal, an abundant supply of water to meet the future requirements of Southern California is assured.

SEWAGE DISPOSAL PROJECTS SHOULD BE COORDINATED

The metropolitan area has some of the longest outfall sewers in the world, including those at Los Angeles and in Orange County cities. As far as the entire metropolitan area is concerned, there has been no well-coordinated plan for sewerage works or for the utilization of water from treatment plants constructed where nuisances would not be created. There has been a strong movement toward the reclaiming of sewage for irrigation purposes and for spreading of water to increase underground storage. Studies have indicated that sewage could be treated, pumped thirty miles against a thousand-foot head, and still be cheaper than some of the local supplies already developed. Two areas are intensively trying to work up projects involving a total of 40 mgd. In the future there is certain to be a coordinated plan worked out on the metropolitan basis to handle all the sewage problems in the metropolitan area. This will of necessity take into account the salvaging of fertilizer and irrigation water.

RAPID TRANSIT PROBLEMS IN LOS ANGELES

The City of Los Angeles and the surrounding territory have no rapid transit facilities. A number of competent reports have been made during the past ten years advocating combined subway and elevated construction. The most recent report advocates an expenditure of $37,200,000 for this purpose. Formation of a successful rapid-transit plan involves combining two street-car companies and twelve independently owned and operated bus services. The average time required for consumers to reach the center of Los Angeles from a 10-mile radius is 50 min. Little wonder, therefore, that automobile traffic is heavy, that parking spaces are limited, and that much time is lost by lack of adequate rapid-transit facilities.

HIGHWAY SYSTEM CALLS FOR STUDY

Southern California, with some of the most heavily traveled roads in the United States, has a highway program which ensures continuous and well-planned extensions in the future. Some study has already been made on an extensive program for the elimination of grade crossings. There is one decided weakness in the present highway plan which authorities are entirely aware of, and that is the practice of permitting real estate to be subdivided along new highways, and business centers to spring up on the highway frontage. In future plans local highway engineers are endeavoring to work up higher-speed arteries which can be restricted so as to better serve the purpose for which they were designed. The Garvey Avenue extension into Los Angeles is a good example of new highway construction. Highway systems constitute a good measure of how effectively communities prepare for future development.

BETTER AIRPORTS NEEDED

Los Angeles is recognized as a hub of aviation industries, including the Lockheed and Douglas plants. Of the 23 airports around the city, there is none within ten miles that complies with A-1-A requirements. In the harbor a plan for combining an air and hydroplane landing field is under way. The provision of sites as near as possible to the Union Depot, fitting in with the proposed rapid-transit plan, is one of the largest engineering problems of the future. Present sites are shown in Fig. 2.

FLEXIBLE PIPES FOR LOADING OIL AT LOS ANGELES HARBOR

CONCLUSION

It is apparent that engineering projects are being shaped to provide a safe foundation on which to base a great expansion of industries, agricultural development, commerical enterprises, and residential areas. Desert homes with air-conditioning equipment on irrigated farms capable of raising early crops are certain to give rise to new self-supporting communities. Under these favorable conditions, Southern California should continue to be a very good place to live.

Construction of Morris Dam

Advanced Methods of Handling Concrete Typify Best Modern Practice

By Verne L. Peugh
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OUTSTANDING structural and hydraulic features have marked Morris Dam as an unusual accomplishment. This paper however is devoted to the construction aspects, which are equally notable. Aggregates were shipped by rail and then conveyed by aerial tramway two miles, rising 500 ft. Cement in bulk arrived by truck and was pumped to the centrally located mixing plant. Requirements of a very dry mix necessitated development of special devices for compacting, including both internal and surface vibrators. These and other interesting side-lights on a successful $5,000,000 operation give Mr. Peugh's paper special value. It was originally presented before the Construction Division on July 4, 1935, at the Los Angeles Convention. A previous description of the project was given in the June 1933 issue of "Civil Engineering" by S. B. Morris, M. Am. Soc. C.E., for whom the structure was subsequently renamed.

MORRIS Dam on the San Gabriel River, completed early in 1934, is a concrete gravity structure. It is 328 ft high from the lowest point of the foundation to the roadway, 245 ft high from stream bed to roadway, 780 ft long, and 280 ft thick at the base. The central 300 ft is straight in plan, and the two ends are curved, the radii of the axes being 716.20 ft. It is conservatively designed, ample allowance being made for uplift and earthquakes; consequently the sections are unusually heavy. The upstream face has a batter of 0.05:1; the downstream face on the straight section has a batter of 0.81:1, and on the curved sections a batter of 0.0875:1 in the upper section, which increases to 0.95:1 at 205 ft below the top.

An excellent résumé of the general project, with design and operating features, by S. B. Morris, M. Am. Soc. C.E., appeared in the June 1933 issue. This paper therefore will be confined to construction problems.

Located at the bow of a hairpin bend in the river, the dam has its right abutment at the end of a spur forming the hairpin. The spillway is an open channel built through and over this spur. Many of the general features and details are shown in Fig. 1. The spillway has a capacity of 80,000 cu ft per sec with water at maximum flood stage; this value corresponds to a runoff of 380 cu ft per sec per sq mile. The greatest flood of record is 40,000 cu ft per sec. The reservoir has a storage capacity of 39,300 acre-ft, and a surface area of 417 acres.

One novel feature of the project was the paving—with a concrete blanket—of the entire upstream face of the spur forming the right abutment, from the river level to a connection with the dam or spillway, or to an elevation above maximum reservoir level. This was done to ensure against percolation under pressure along any seam or crevice through this relatively narrow ridge. Over 180,000 sq ft were paved with heavily reinforced concrete having a nominal thickness of 8 in. at the top and 26 in. at the bottom, but with a much greater actual thickness, due to irregularities in the rock surface.

VIEWED AS AN ENTITY

Designed for the storage and diversion of water for domestic use, Morris Dam was constructed by, and is owned and operated by, the Pasadena Water Department. An agreement has been made between the city and the Metropolitan Water District of Southern California whereby the dam will be acquired by the District and used for local storage of Colorado River water at such time as the District has completed its aqueduct and is prepared to furnish water to the city.

Construction of the dam involved the removal of approximately 600,000 cu yd of earth and rock, and the placing of approximately 500,000 cu yd of concrete, nearly 5,000,000 lb of reinforcing steel, and more than 4,000,000 lb of gates, valves, pipes, and other metal work. The latter item was unusually heavy for a dam of this size. The cost of the dam proper was $4,850,000. Other necessary features, such as lands and rights of way, a 36-in. pipe line from the dam to Pasadena, and relocation of the San Gabriel Canyon Highway, brought the total cost of the project up to $7,600,000.

In the contract, which was executed on April 25, 1932, provision was made for completing the dam to such a stage as to utilize the full-storage capacity of the reservoir in time to catch the runoff of the winter of 1933–1934. Thus only about 20 months were allowed for the essential parts of the work. This demand for speed was constantly in the minds of all those connected with the project, but at the same time the demand for work of high quality was made of paramount importance. In tightness, strength, efficiency of operation, and other desirable features, the finished structure has proved entirely satisfactory.

From a construction viewpoint, the chief characteristics of the work were: (1) a short flood season, reducing the cost of diversion; (2) location within four miles of an existing commercial rock plant, making it unnecessary to install a special plant for the job; (3) use of an aerial tramway two miles long for bringing aggregates to the dam; (4) a concrete plant centrally located between the dam and the spillway and readily accessible

Surface Vibrator at Work
Operators Stand on Base of Machine

also to the slab on the upstream face of the west abutment; (5) cement delivered in bulk by tank trucks; (6) cableways for distributing the concrete; and (7) the use of concrete too dry to be worked efficiently by hand methods, and consequently requiring vibrators.

EXCAVATION METHODS SPECIALIZED

As in all masonry dams, the two items of major interest from a construction standpoint were foundations and concrete. These will be briefly treated in order. The rock at the dam site is chiefly a granodiorite gneiss. Associated with the gneiss are small intrusions of diabase and aplite, the former as dikes and the latter principally in irregular masses, or lenses. The region is characterized by a high degree of jointing, and by numerous small slips and faults, upon which relatively small movements have taken place in the remote past. This jointing and faulting have encouraged weathering, and in some places, particularly on the right, or west, abutment, have required deep excavations in order to find fresh rock for a suitable foundation.

HAULING CEMENT FROM MILL TO SILO AT DAM SITE
Truck and Trailer Combination Proves Efficient

In order that the final foundation might be undisturbed, blasting was strictly regulated. The depth and spacing of holes, the amount of powder in any hole, and the total amount of powder exploded at one instant, were all limited, the degree of limitation depending on the location of the blast. For instance, within 10 ft of the estimated position of the foundation, the depth of holes was limited to 5 ft, and only two or three sticks of powder were used in each hole. In the cut-off trenches the maximum depth of hole was 3 ft.

After a satisfactory foundation was reached, it was finally trimmed and shaped by picks, bars, and wedges, without using powder. Because of the jointed character of the rock, this final clean-up became a major operation, involving several thousand cubic yards. All loosened blocks were removed, seams and other defects were cleaned out and their effects minimized as far as possible, and the whole area was so shaped as to give the best possible bearing surface.

In the cut-off trench, several shafts, ranging from 10 to 150 ft in depth, were excavated along small faults which crossed the trench, and were filled with concrete, forming a plug to stop any percolation. The trench itself was of generous size, having a minimum width of 8 ft and varying in depth from 10 to 40 ft.

CONCRETE HANDLED EFFICIENTLY

While the excavation work was under way, the concrete plant was being planned and erected. The mixing plant, located at the top and on the right end of the dam proper, consisted of two 4-cu yd tilting mixers, a batching plant for each mixer, and bins for aggregate and cement above the batching plants. Aggregates were weighed cumulatively in a single large hopper, the weights registering on a dial having cut-off pointers. The delivery of aggregates was regulated by air-operated radial gates manually controlled. Cement was fed into special covered hoppers by metering devices and screw conveyors, with automatic cut-offs controlled by beam scales. Water was measured by automatic meters into vertical tanks equipped with calibrated glass gages for instantaneous visual check. The mixing operation was at all times under the supervision of an inspector, who received orders for concrete, set the water meters and scales, checked the water content of the aggregates, and was fully responsible for the quality of the concrete turned out.

The specifications called for mass concrete too dry to be chuted, and furthermore forbade the use of chutes or belts, insisting that the concrete be placed by bottom-dump buckets. These buckets were transported on two 15-ton cableways. Both were attached to a common, fixed head-tower behind the mixing plant, and passed over that plant and across the dam site to individual movable tail-towers on the left abutment. These cableways, which were 960 ft long, had carriage speeds of 1,200 ft per min and hoisting speeds, using four-part lines, of 300 ft per min. Each bucket held 4 cu yd, or one batch, and weighed, loaded, about 11 tons. The tail-towers, operated by remote control from the hoist house at the head-tower, traveled at 150 ft per min. The first track cables used were $2^1/_2$-in. lang-lay hemp-center wire ropes; these showed excessive wear after a short time and were replaced by $2^1/_4$-in. lock-coil cables, which operated satisfactorily.

MORRIS DAM COMPLETED—GENERAL VIEW FROM CANYON BELOW
Spillway at Left, and Outlet Structures at Foot of Dam

Because of the great weight and slow travel of the tail-towers, they could not well be moved for each bucket of concrete; consequently lateral movement was accommodated by a shuttle track in front of the mixing plant operated by gasoline locomotives and carrying two cars, one for each mixer-cableway unit. Each car held two buckets. Concrete was dumped from the mixer on to a short belt, thence was delivered to an empty bucket on the car, and carried to a point under the corresponding cableway. The incoming empty bucket was set down on the car by the cableway, and the full one was picked up and carried to the forms while the shuttle car returned for another load. The complete exchange of buckets, including lowering, landing, unhooking, hooking, and hoisting, required about 45 sec.

It was necessary to mix the concrete for three full minutes after all ingredients were in the mixer. During the period of heavy production the regular operation cycle was slightly under 4 min; in some instances an average of 3 min 45 sec was maintained for a full 8-hr shift, with the full mixing time for each batch.

AERIAL CABLEWAY SOLVES PROBLEM

Aggregates were river sand and gravel furnished by a commercial plant in the valley below the dam site. At the gravel plant, they were divided into five sizes, ranging from sand to 6-in. cobbles, and were hauled 2 miles by railroad to the mouth of the canyon, where they were stored in stock piles. From the stock piles they were drawn by a belt in a tunnel and delivered to the loading bins of an aerial tramway's lower terminal.

This cableway was 10,200 ft long, rising 500 ft to the discharge terminal at the dam site, much of the rise being in one span. It followed two straight courses, having one horizontal angle of 28 deg. Two special structures were required—one at the horizontal angle and one at the top of the steepest span—to provide for an otherwise excessive vertical angle. Operation through these structures, as well as on all other parts of the line, was entirely automatic. The driving mechanism, actuated by a 150-hp variable-speed motor, was at the upper or discharge terminal, at the top of the mixing plant at the dam. Aggregates were dumped directly into the bins over the batching plants.

POURING CONCRETE BLANKET ON RIGHT ABUTMENT
Cableway Tower and Spillway Above

The track cables, of lock-coil construction, were $1^5/_8$ in. in diameter on the loaded track and 1 in. in diameter on the unloaded track. The traction line, a 1-in. lang-lay hemp-center wire rope, traveled at 500 ft per min. Buckets of 32-cu ft capacity, with a loaded weight of 5,000 lb, were automatically dispatched at intervals of 214 ft. The capacity of the tramway was 235 tons of aggregate per hour.

In the stockpiles at the lower terminal was storage

WORKING THE DRY-MIX CONCRETE
Internal Vibrators Are Electrically Driven

capacity sufficient for aggregates equivalent to 4,000 cu yd of concrete. At the upper terminal, storage equivalent to 500 cu yd of concrete was provided. Normal concrete production was 2,000 cu yd per day, when operating at full capacity.

Bulk cement was hauled from the cement plants in tank trucks and trailers, 114 barrels (about 21 tons) to the load, and was delivered on the lower road at the base of the dam. During the period of heaviest demand, from 18 to 20 loads per day were used. The longest haul was from Victorville, Calif., 80 miles away. At the point of delivery, the cement was dumped into a hopper by opening the rear end of the tank and lifting the other end with an overhead hoist installed in the terminal building, much as one would empty a can by turning it upside down. From this hopper it was transported, by a screw conveyor and bucket elevator, to a nearby steel silo with a capacity of 4,000 bbl.

From the storage silo, the cement was pumped through a 5-in. pipe 800 ft long to the mixing plant at the top of the dam. The point of delivery was 300 ft above the pump. This lift was greater than any against which cement had been pumped up to that time, but very satisfactory operation was secured. The capacity of the pump was from 125 to 140 bbl per hr.

VIBRATORS PERMIT STIFF MIX

On September 8, 1932, just four months and thirteen days after the contract was signed, the concrete plant went into production. In spite of this very short period for design and construction, its operation throughout the job was very efficient, and in every way satisfied the requirements of both the contractors and engineers.

Because of the very dry concrete

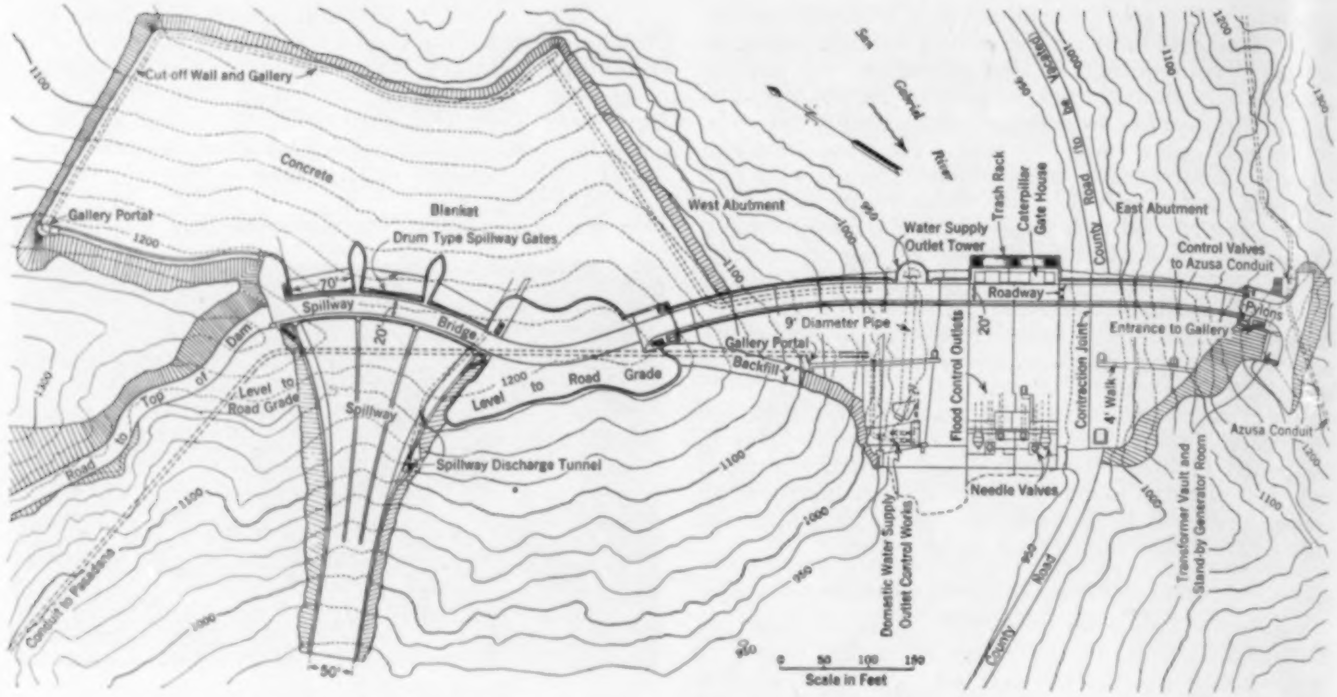

FIG. 1. GENERAL PLAN OF MORRIS DAM AND APPURTENANT WORKS

specified—too dry to be worked by hand methods—it was practically mandatory that mechanical vibrators be employed. The concrete actually used for the bulk of the dam had a slump of from zero to 1 in., averaging $^1/_2$ in. It was of such consistency that one could walk across freshly worked concrete wearing low shoes and soil only the bottoms of the soles.

Although not the first dam in which vibrated concrete was used, Morris Dam was one of the earliest in this phase of construction. In addition to benefiting by the use of vibrators, the dam was used by manufacturers as a testing ground. Particularly did it help in the development of more efficient equipment for internal vibration of mass concrete.

Two types of equipment were used as standard for the mass concrete—an internal vibrator and a surface vibrator. The electrical units were practically the same on both. On the internal type the vibrator was mounted on the end of a long handle and was thrust deeply into the concrete, being operated by one man; whereas on the surface type a similar unit mounted on a wooden shoe, 2 by 12 by 36 in., was operated by two men, who bore their weight upon it while it rested on the surface of the concrete. This equipment was built to operate at 60 cycles, but only 50-cycle current was available. This frequency was too low for efficient operation, and it became necessary to install a special motor-generator set to increase the speed of the vibrators. Tests showed that the greatest efficiency was obtained with a frequency of about 75 cycles, and since the equipment proved sufficiently strong, that speed was used throughout most of the work.

The concrete was deposited in 4-cu yd batches. It was first thoroughly worked by three men using internal vibrators, which process consolidated the mass, and then, for the final compaction, the surface vibrator was used. Both types of vibrators were needed for proper working of the mass concrete, although internal vibration alone was sufficient for the softer mixes used in the reinforced concrete work.

During the processes of vibration described two muckers picked up stray cobbles and placed them where they would be incorporated in the fresh concrete, separated rock clusters, and trimmed up the edges of the batch. The concrete crew consisted of eight men—three men, each with an internal vibrator; two men operating a surface vibrator; two muckers; and a foreman. This crew and equipment was sufficient for the thorough working of concrete placed at the rate of 1 cu yd per min.

In the spillway and west abutment lining, most of the concrete was made up of aggregates of $1^1/_2$-in. maximum size, and had a slump of from 3 to 5 in. Chutes were permitted in those places, but they were required to be steep enough to transport concrete of such consistency efficiently. The minimum slope was 6 on 12. This concrete was consolidated with internal vibrators, an air-driven machine of tubular form being used.

In spite of the natural hazards of dam construction, the accident record was very good, and won special commendation from the insurance company which carried the risk.

Construction work began April 26, 1932, by a group consisting of Bent Brothers, Inc., of Los Angeles, Calif.; the Winston Brothers Company of Minneapolis, Minn.; and William C. Crowell of Pasadena, Calif. These organizations undertook the work as a joint venture, being low bidders with a total cost of \$2,412,000, based on estimated quantities. The city furnished cement and practically all materials incorporated in the completed work except concrete aggregates. Due to some increases in actual quantities over the original estimates, the actual payments under this contract amounted to \$2,727,000. Concrete work was practically finished in January 1934, and the project was entirely finished and accepted on June 12, 1934. It was conceived, developed, and executed under the supervision of Samuel B. Morris, M. Am. Soc. C.E., chief engineer and general manager of the Pasadena Water Department. As a token of esteem from the community for his long and efficient service the project has been given his name, a fitting and well-deserved honor for him and also for the engineering profession.

Large Concrete Pressure Pipes

Siphons Up to 12 Ft as Built, Installed, and Tested on the Colorado River Aqueduct

By N. D. Whitman

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DESIGN of large-sized pressure pipes for aqueducts has made notable advances in recent years by the adaptation of reinforced concrete to high heads. Watertightness is ensured by a welded inner shell supplemented by special metal joints, lead caulked. With or without the shell, heavy welded reinforcement in one or more layers is accurately placed in the forms, and the lengths, up to 12 ft, are pre-cast vertically. Although the materials are tested before installation, the finished line is subjected to an extensive pressure test. Maximum sizes seem to be about 12 ft in diameter, governed by the limiting weight of 40 tons. Many practical problems of design, fabrication, and construction are treated in this article abstracted from a paper presented on July 4, 1935, before the Construction Division at the Los Angeles Convention.

REINFORCED concrete pressure pipe has been gradually developed in this country since 1910 but until about 1925 the working head was restricted to around 100 ft, and this for pipe diameters up to 7 or 8 ft. These limitations were due largely to the difficulty in producing concrete which would be watertight under higher heads, to the inefficiency of the joints, and to the problems presented in handling larger and heavier pipe. The earlier types of joints would not stand any material longitudinal movement without leaking and so were suitable only for lines where the water was of a fairly uniform temperature throughout the year and frost did not reach the pipe. Under favorable conditions, these old lines have rendered satisfactory service.

With the introduction in 1923 of cylinder pipe, providing a watertight membrane in the wall with metal joint rings attached, the previous difficulties were overcome, both as to watertightness of the pipe wall and of the joints. The latter were designed to be self-centering, so that a preformed lead gasket could be caulked between the bell and spigot joint rings, producing a joint that was capable of withstanding longitudinal movement without leaking.

CYLINDER AND BAR TYPES USED

This pipe is produced in two types: cylinder pipe having a relatively light metal cylinder membrane with one or more reinforcement cages outside, which is ordinarily used for heads exceeding 80 to 100 ft; and bar pipe, used for lower heads—a reinforced concrete pipe having one or more cages of reinforcement with the cage longitudinals welded to the joint rings.

While the early reinforced pipe was usually made in 3 to 5-ft lengths, the trend has been toward longer sections, and today 12 ft is standard, although 16 and 20-ft lengths have been produced. This dimension is primarily a question of economics. The longer the lengths, the lower the unit cost of joint rings, pipe manufacture, and laying and caulking of joints; but the length is limited by construction conditions and the availability and cost of equipment for handling the pipe, which in the large sizes is extremely heavy. A 12-ft length of pipe 12 ft in diameter weighs approximately 40 tons.

Pre-cast pipe has these advantages over that cast in place: a uniformly denser concrete with a smoother interior surface can be more easily obtained where sections are cast on end than where the concrete is poured around horizontal forms; and the shrinkage in the concrete due to the setting of the cement takes place in the pre-cast sections before they are laid, while in the monolithic pipe, to prevent cracks, this must be taken care of by longitudinal reinforcement, by expansion joints, or by both.

Any type of joint, in order to be watertight under expansion and contraction, must have one face smooth and parallel to the axis of the pipe, against which the joint material is held. Under these conditions, the joint material remains tight against the opposing surface of the joint throughout any longitudinal movement.

SOME HINTS ON DESIGN

Large reinforced concrete pressure pipes are designed to withstand the external loads as well as the internal pressure, with suitable allowance for pressure surge where necessary. All tensile stresses in the pipe walls are carried by the steel cylinder and reinforcement. The steel stress due to internal pressure is based on the internal diameter in the bar pipe and on the internal diameter of the cylinder in cylinder pipe. The usual allowable working stress in the steel cylinder or reinforcement in direct tension is from 12,000 to 13,500 lb per sq in. and for combined bending and tension from 18,000 to 20,000 lb per sq in. For concrete in compression, a working stress of four-tenths the compressive strength is commonly used. Concrete with 4,000-lb strength is easily made, and 5,000-lb strength can be obtained when necessary. The working strength for concrete in pressure pipes is usually from 1,200 to 2,000 lb per sq in.

Some assumption must be made by the designer as to the support which the pipe will have when laid. It is often specified that the bottom of the trench shall be shaped to fit the lower 90 deg of the pipe. In most soils and especially with large pipe it is extremely difficult, if not impossible, to secure such a uniform bedding. With pipe 7 ft in diameter, or larger, the only sure method is to pour a concrete cradle under the pipe after it is laid. This concrete should be very wet and contain plenty of

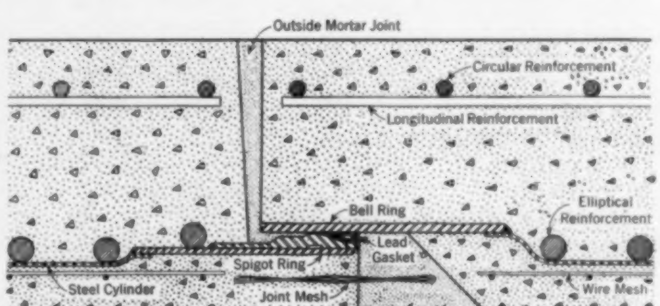


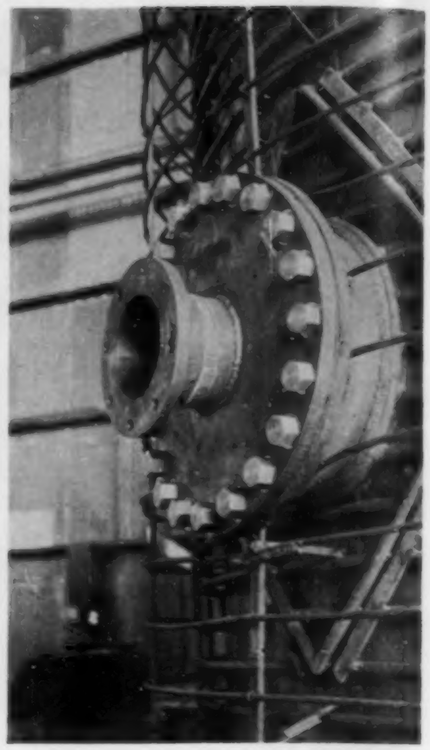
Fig. 1. Joint for Steel Cylinder Pipe
Details on Vertical Section at Top

CURVED SECTION OF CYLINDER, TEMPORARILY CONNECTED TO FIT SPACER BARS

Sections to Be Later Welded in Place

BEND OF 45 DEG ON LITTLE MORONGO SIPHON BUILT IN PLACE

Pipe 12 Ft in Diameter Poured from Above



MANHOLE OUTLET AS ATTACHED TO REINFORCING BEFORE CONCRETE IS POURED

Extra Bracing Strengthens Cage Assembly

sand, so that it will readily run in under the pipe. Since the load on this cradle will never exceed 100 lb per sq in, strength is not a requisite. One part cement to 12 or 15 parts aggregate will give just as satisfactory results as richer mixtures. In order to economize on concrete, the bottom of the trench is usually shaped so that the maximum thickness of concrete will not exceed 8 to 12 in.

Dead and live loads on the pipe are usually computed by the formulas proposed by Anson Marston, Past-President Am. Soc. C.E., in Bulletin No. 96 of the Iowa Engineering Experiment Station. These are based on his research work during the last 25 years, which has shown that the weight of backfill on a pipe laid in a trench varies as the square of the width of the trench at about the top of the pipe. It is essential, therefore, that this trench width be carefully determined before the pipe is designed, taking into consideration the nature of the soil and the working space required in laying. As a precaution against carelessness in exceeding the necessary trench width and thereby increasing the load on the pipe, it is well to establish a maximum allowable width which, if exceeded, will require additional concrete cradle at the contractor's expense, to compensate for the additional load on the pipe.

ACCURACY ATTAINED IN MANUFACTURE

The cylinders for large pipe are usually fabricated by welding the necessary number of flat sheets, usually No. 8 to No. 12 U. S. Standard gage, and then rolling the large sheet. After the joint rings are welded to the ends of the cylinder, it is tested either under air or water pressure for leaks. It must be watertight before being placed in the pipe.

Reinforcement assemblies of circumferential steel are composed either of individual hoops or of continuous spirals and are attached to the longitudinal bars, mechanically or by welding. When hoops are used, they are made by rolling bars into circles and butt welding the ends together, after which the weld is tested to twice the allowable working stress. Bars for spiral reinforcement are usually purchased in 80 to 100-ft lengths and butt welded. The welds are tested to twice the allowable working stress, and the continuous bar goes to the machine, where it is coiled to the proper diameter. Circumferential bars are held in their proper position by spacing brackets welded to the longitudinals. When the assembling is completed, the cages are rigid and ensure the proper location of the reinforcement. Reference to Fig. 1 will show the relation of reinforcement, especially in connection with the joint details.

Joint rings are made by rolling lengths of bars of proper cross section and butt welding, forming rings slightly smaller than required, and these are stretched beyond the elastic limit of the steel to exact size in a hydraulic press. Only in this way can all of them be made exactly alike, which is essential, as the clearance between the outside of the spigot and the inside of the bell is less than $^1/_{16}$ in. This accuracy and close fit of the joint rings is necessary so that any spigot will fit any bell and so that the clearance will not permit the lead to flow through in caulking. As it is also necessary that the joint rings be exactly round, they are held truly circular by rigid machined rings when the pipe is cast.

Since the pipes can be no better than the forms in which they are cast, the Metropolitan Water District of Southern California, in its specification for the Colorado River Aqueduct, permitted a variation of only $^1/_{32}$ in. in the diameter of the inner form for 12-ft pipe. Such close tolerances can be met by any well-equipped shop with careful workmanship. Pipe cast in such forms, when carefully laid, ensures that the finished pipe line will have a uniform cross section, free from offsets or distortion at the joints.

Pipe sections are cast vertically in steel forms with

cement-tight joints and enough rigidity to prevent any distortion. As the forms are filled, powerful vibrators, attached to rails welded to the forms, are raised, keeping them slightly below the level of the concrete. At the same time, the concrete is spaded adjacent to the inner and outer form.

LAYING PIPE AND MAKING CONNECTIONS

Because of their weight, sections of large pipe have to be jacked into place for the last few inches. On steep slopes where it would be difficult to operate either crane or gantry, the pipe may be carried to the top of the slope and then slid down the trench on rails laid to grade in concrete and left in place. After the pipe is in place, the lead gasket is lightly caulked from the inside of the pipe to seal the joint, and the space between the sections on the outside is poured full of grout. The concrete cradle and earth backfill is then placed, and later, when convenient, the lead gasket is given its final heavy caulking, using an 8-lb sledge, and the inside recess at the joint is filled with mortar and finished smooth and flush with the inside of the pipe.

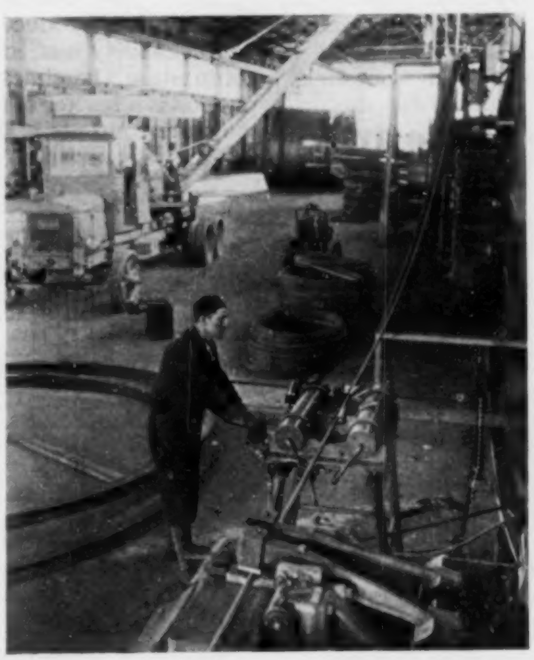
Minor deflections in vertical or horizontal alignment may be permitted with straight pipe, with deviations at each of several joints. Where greater deflections are necessary, the pipe is made with an angle on the spigot end not exceeding 5 deg. Curves have a center line radius usually of $2^1/_2$ to 3 diameters, made by fabricating a steel bend with joint rings and reinforcement assemblies attached. This is laid in the line between the adjacent straight sections. Concrete, similar to that used in the pipe, is cast on the outside, and the inside is lined with mortar.

When the thrust at bends due to internal pressure and velocity is greater than can be safely carried by concrete backing on the outside of the curve, tension joints are provided by welding together the bell and spigot rings on either side of the bend for a sufficient distance to safely anchor the bend. Openings in the line for manholes, blow-offs, and air valves are of cast steel, welded to the reinforcement assemblies and to the steel cylinder when used. Additional reinforcement is provided to compensate for the cutting of bars and cylinder at the opening.

End connections with steel pipe are made by welding the steel pipe to a joint ring either directly when the size permits, or by means of a short taper section. The concrete lining is tapered to make a smooth transition and is reinforced with steel mesh, spot welded to the steel pipe.

PIPES UNDERGO RIGID TESTS

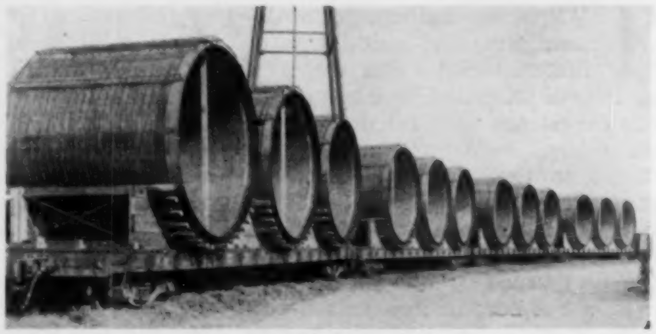
Because of the high costs and difficulties presented in making hydrostatic tests on individual sections of large reinforced concrete pipe, testing is restricted to the completed line. Unlike metal pipe, reinforced concrete pipe should not be subjected to the full pressure immediately upon filling, but the line should be allowed to stand under a moderate pressure until the concrete has had time to absorb what water it may and any trapped air has escaped or been absorbed.



TESTING BUTT WELDS ON 1-IN. RODS BEFORE THEY GO TO THE COILING MACHINE

This also relieves the reinforcing steel of any compression stresses set up by shrinkage. The line test may continue from 2 hr to 2 days, as the engineer specifies, although tests from 4 to 12 hr are most common and seem to give the same information as do those continued for longer periods.

In making short tests, usually a constant pressure is maintained by admitting water as required, the amount being measured through a meter or by taking the water from a tank. For longer test periods, the pressure is brought up to that required and the line allowed to stand for 10 or 12 hr, or until the pressure has dropped a specified amount, when the pressure is again raised to that required, measuring the volume of the water required. In either case, the leakage in the line is the amount of water admitted, less any measurable amount lost at valves and bulkheads, which cannot be made watertight. Leakage varies with the conditions under which the work is done, but the average is well under 75 gal per in. of diameter per mile per 24 hr, with some lines showing less than 5 gal.



PIPE READY FOR SHIPMENT TO THE JOB
Reinforcement Assemblies on Flat Cars in Los Angeles

Large concrete pipes have a high carrying capacity due to the uniform internal cross section and the smoothness of the interior surfaces. Coefficients of retardation of $C_w = 140$ in the Hazen-Williams formula, $C_s = 0.370$ in the Scobey, and $n = 0.012$ in the Kutter formula are easily obtained. The latter formula is not recommended by most authorities for closed lines under pressure. With careful laying under average conditions of alignment and velocity, values approaching or even exceeding $C_w = 150$, $C_s = 0.400$, and $n = 0.011$, respectively, may be expected. According to Scobey, in Bulletin 150 of the U. S. Department of Agriculture, there is apparently little change in the carrying capacity of concrete pipe with age.

The only limit to the size is that due to weight. The cost of handling, transporting, and laying extremely large pipe will undoubtedly restrict its use in competition with other materials, except where allowance is made for greater sustained carrying capacity, longer life, and lower maintenance cost.

Selecting Materials for Rolled-Fill Dams

Requirements Analyzed and Optimum Mechanical Analyses Proposed

By Charles H. Lee

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IMPROVEMENTS in earth-handling equipment have resulted in cheaper and better rolled-fill dams so that this type is finding for itself a definite place in the field of hydraulic construction. That being true, new and improved methods of selecting the component materials are demanded. Mr. Lee addresses himself to this problem, considering such requirements as stability, watertightness, workability, insolubility, and cost. Based on his studies, he proposes graphical definitions of mechanical analysis to satisfy the first three requirements. This article represents an abbreviated treatment of a much more comprehensive paper presented on July 4, 1935, before the Irrigation Division at the Society's Convention in Los Angeles.

THE traditional manner of determining the suitability of material for earth dams is exercise of judgment based on previous experience and aided by sense testimony such as appearance, "feel" to the hand, and possibly grittiness between the teeth. In late years, with an increase in the number and size of earth dams and the occurrence of unexpected failures, it has become apparent that a more scientific method of selection was needed. The first efforts in this direction were in connection with hydraulic-fill dams, where knowledge of the size of particles and other physical properties of materials was found essential as a guide to safe and permanent construction methods.

Recent improvements in mechanical equipment for handling earth have so reduced the cost of rolled-fill construction that this type is now an economic competitor of the hydraulic fill. In addition, because of its freedom from the element of unpredictable failure during construction, rolled fill is becoming a more popular type of construction. It has this disadvantage, however, that failure, if it occurs, does so when the structure is in service and after it has had full opportunity to absorb water. For this reason and also because practical earth-testing methods have now become more or less standardized in other lines of technical activity, such as highway construction, the present tendency in rolled-fill construction is toward the use of scientific earth-testing methods. This tendency extends both to the selection of material and the control during construction. The present paper treats of earth testing as an aid to selecting materials. The requirements for suitability of material for the impervious part of a rolled-fill earth dam are: (1) permanent stability, (2) reasonable watertightness, (3) workability, (4) insolubility, and (5) reasonable cost.

Stability is a function of high internal friction produced by the rubbing together of bulky granular particles held in contact by the forces of cohesion. These cohesive forces depend on the molecular attraction exerted by water films and moist clay particles between granular particles separated by minute distances of the order of 0.0000002 in. and less. Such forces are brought into action through compaction of the material by use of appropriate mechanical equipment at a critical moisture content. Grading of particle sizes is an important aid, because it provides greater density. For maximum cohesion the clay content should slightly exceed that required to fill the voids between granular particles, thus allowing compaction to occur without completely closing the gap between individual grains. With a well-graded material, a clay content of as low as 3 per cent may be sufficient. In a poorly graded or ungraded material a greater percentage is necessary. On the other hand, it is impossible to compact clay without the inclusion of air, which is replaced by water after the dam is in use, and may ultimately produce sloughing. A clay content of 30 per cent by weight is a desirable maximum limit for ungraded materials.

Watertightness depends both on density and on the existence of minute spaces between particles. Like stability, it is produced by grading and compaction.

Workability is affected by requirements such as ease of compaction, harshness, and stickiness. Ease of compaction is a matter of regular grading and proper clay and moisture contents. Harshness can be avoided by limiting the maximum size of cobblestones and by the use of

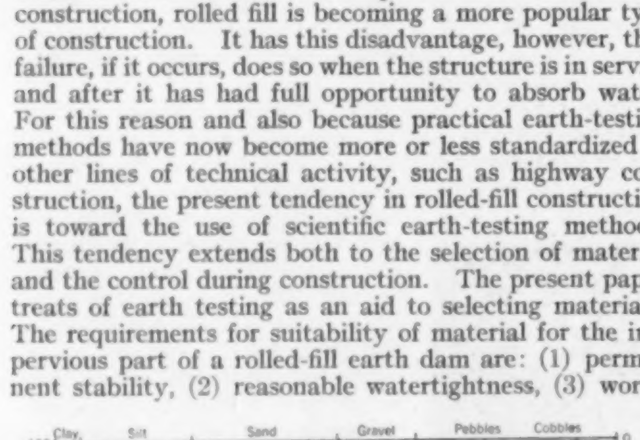

Fig. 1. Proposed Limits in Mechanical Analysis for Graded Materials Suitable for Impervious Sections of Rolled-Fill Earth Dams

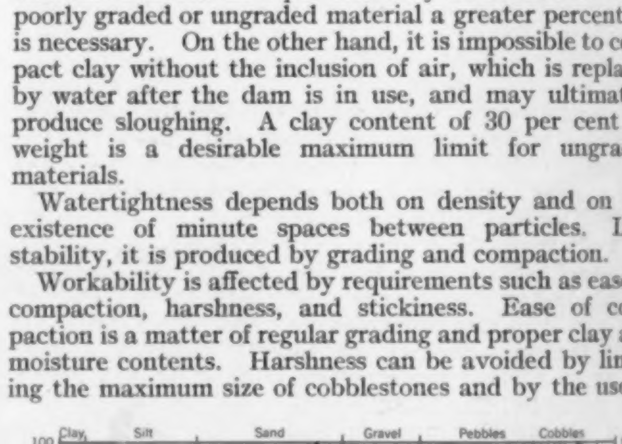

Fig. 2. Proposed Limits in Mechanical Analysis for Ungraded Materials Suitable for Impervious Sections of Rolled-Fill Earth Dams

finely graded material. Stickiness results from a high clay content or the attempt to work material immediately after the application of water.

These findings are supported by field experience and results of tests by the Pacific Hydrologic Laboratory and other earth-testing laboratories.

Of the five requirements for suitability, the three most important are stability, watertightness, and workability. There is an intimate relation between each of them and the mechanical composition of the material. Stability and watertightness are both secured as a result of regular grading of particle sizes and compaction of material; grading is entirely a matter of mechanical composition. Compaction, in order to be permanently effective, necessitates limits for the clay and silt fractions. Workability also involves limits both for fine and coarse fractions. This suggests the possibility of using mechanical analysis as a preliminary basis for selection of material.

Examination of mechanical analysis curves for a variety of materials discloses great divergence in slopes, curvature, and terminal points. Even between fixed terminal points an almost infinite number of curves are possible. As the extremes result from variation not only in particle size but also in grading, it is apparent that if any method of selection based on mechanical analysis is to be successful, it must include limits not alone of size, but also of departure from regular grading. If specified from the graphical standpoint, this means that on the mechanical analysis diagram, limits in shape and slope of curvature must be considered as well as limits in area. To accomplish this, it is proposed, first, to set up limits of particle size for coarse and for fine materials; and second, to prescribe curvature limits based on both degree and fineness of grading.

Two sets of limiting curves are desirable, one applying to regularly graded materials and the other to ungraded materials. Between these limits will lie the poorly graded materials. The tabulations, graphically illustrated by Figs. 1 and 2, set forth the proposed specifications for limiting curves for graded and ungraded materials. In using these charts for materials having a maximum size between 5 in. and 0.6 mm, intermediate curves generally parallel to the limiting curves should be plotted. In the case of Fig. 2 such curves should not cross the lower arm of the maximum limit. These specifications are designed to fulfill the requirements for stability, watertightness, and workability.

Sheepsfoot Roller Compacting Fill in Cut-off Trench
Thin Layers of Earth Are Kneaded and Rolled at Calero Dam, Santa Clara Valley Water Conservation District, Calif.

End of Cut-off Trench at Calero Dam
Showing a Modern Rolled-Fill Type of Construction, with Grader and Sheepsfoot Roller at Work

In applying the proposed limits to determine the suitability of a material, it is not sufficient that the mechanical analysis curve should lie between the respective coarse and fine limiting curves; it must also have a shape corresponding to or approaching that of the limiting curves. If it does not have sufficient upward concavity to fit or approach the curvature of limiting curves for graded material, it may then be compared with the limiting curves for ungraded material. If it has too much downward concavity to follow or approach these curves, the material may be unsuited for use in the impervious part of a rolled-fill dam. The deciding factor is then the clay content, which should slightly exceed that required to fill the voids in the granular part.

The selection of material from mechanical analysis data, although believed to be practical, is more or less preliminary in character at the present time and subject to the results of more positive tests, such as those for compaction and permeability.

Some Forward Steps in Sanitation

Both New and Established Methods Used to Good Advantage in Western Cities

WATER supply and sewage disposal problems on the Pacific Coast have been capably solved in a number of recent instances, either through modern refinements of old-established practices or by the use of research developments based on the newer theories. Adaptations of older methods are illustrated in two of the following papers—that by Mr. Derby, on improvements in chlorinating the water supply of Los Angeles, and that by Messrs. Frickstad and Ribal on the disposal of Oakland's refuse at sea. After familiar processes had been apparently found wanting at Los Angeles and Oakland, these processes were perfected so as to achieve an efficient and economical result. The use of scientific devices founded upon the more recent theories is illustrated in the articles on the Pasadena Tri-City Sewage Disposal Plant by Messrs. Hincks and Hedrich. These authors deal respectively with the production of fertilizer from disposal-plant sludge on a commercial basis, and the development of a scientific means for odor control. All four articles have been prepared from papers delivered on July 4, 1935, before the Sanitary Engineering Division at the Los Angeles Convention of the Society.

Chlorinating Method Improved at Los Angeles

By Ray L. Derby

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THERE are two principal sources for the water supply of the City of Los Angeles. The Los Angeles aqueduct, with a flow of about 250 to 300 cu ft per sec, supplies all of the San Fernando Valley and the western and southern parts of the city. The Los Angeles River, with a capacity varying from 70 to 90 cu ft per sec, serves the northern and eastern sections of the city and combines with the aqueduct to supply the central part of the city. In addition, there are several groups of wells pumping directly into the distribution system. These wells are principally standby units, being used mainly in summer, and some have not been operated for several years.

The aqueduct supply has its source in the snows of the High Sierras, 250 miles north of Los Angeles, at elevations of 7,000 to 14,000 ft. These mountain streams either enter the Owens River, which is subsequently diverted into the aqueduct, or enter the latter directly. The watershed is largely rugged mountains or barren desert, with a few small towns and farms. There are no sewers discharging into any of these streams, and permanent population is less than 2 per sq mile. Cattle customarily graze on the lower mountain slopes, and for three or four months there is a large transient population of vacationists, in some years approaching a million.

Haiwee Reservoir, which affords storage for about three months, is located 60 miles below the aqueduct intake in a bleak valley having no resident population on its watershed. Bacterial analyses above this reservoir show slight contamination, with about 30 per cent of all 10-cc tubes positive, and 25 per cent of the samples having three or more tubes positive. Contamination has been reduced to such an extent by passage through the Haiwee Reservoir that during the past year water leaving the reservoir has shown only 2 per cent of the 10-cc tubes positive and no samples with three or more tubes positive.

From the Haiwee Reservoir the water is carried by closed conduit across 180 miles of desert to Los Angeles, except where it emerges at Fairmont and Dry Canyon reservoirs. These have small storage capacities but

Mulholland Chlorination Station, Los Angeles
An Attractive Exterior Typifies Newer Stations of the Department of Water and Power

are located in a dry desert region and have no resident population on their watersheds.

The aqueduct approaches Los Angeles through the northwestern part of the San Fernando Valley. About 28 miles from the city, the first diversion is made by the Maclay high line, a gravity line with a flow varying from 6 to 60 cu ft per sec. As there is some possibility of bird and cattle pollution at Dry Canyon, a chlorinator is located near the beginning of this line. A residual of chlorine is necessary to counteract any possible seepage entering from local sources.

Below the Maclay high line the water enters Upper San Fernando Reservoir and then Lower San Fernando Reservoir. A railroad and main highway cutting across this watershed, together with several ranches and subdivisions, cause fairly heavy pollution in the upper reservoir immediately following rains. At times as high as 70 per cent of all 10-cc tubes are positive, and samples have three or more tubes positive. It is therefore considered advisable to treat the outlets of these two reservoirs during the rainy season.

One treatment plant is on the Chatsworth high line, which is diverted between the upper and lower reservoirs and ends at Chatsworth Reservoir, and the other treats the two outlet lines from the reservoir. The Chatsworth line is a gravity line similar to the Maclay, with a yearly variation in flow of 9 to 136 cu ft per sec. The San Fernando outlet lines are the San Fernando Valley trunk, a 54-in. line, and the Los Angeles City trunk, a 72-in. line, both under pressure.

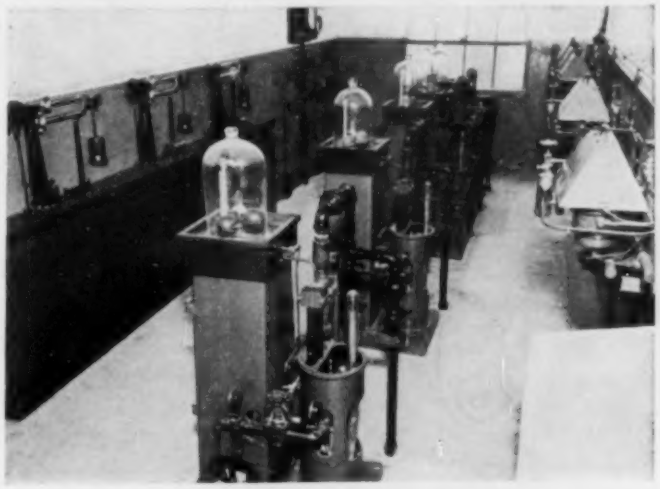
There is a chlorine station at the outlet of the Chatsworth Reservoir which is not at present equipped or in use. The watershed of this reservoir is well protected; the reservoir is fenced; and storage is long. Bacterial analyses show this water easily able to meet the U. S. Treasury Department standards. During the winter this station can be by-passed and there will be little need to use it for some time.

The 54-in. San Fernando line, after serving the central part of the San Fernando Valley, cuts through the Santa Monica Mountains to enter the Stone Canyon Reservoir. The outlet of this reservoir was chlorinated for several years, but as the situation here is even better than at the Chatsworth Reservoir, treatment was discontinued about $2^1/_2$ years ago, resulting in a considerable saving in operating costs. The 72 in. line from the San Fernando Reservoir divides, one part piercing the mountains to enter the Upper and then the Lower Franklin Canyon Reservoir, the other swinging eastward to pass through the Hollywood Hills and enter the Upper and then the Lower Mulholland Reservoir.

Originally the Franklin chlorine station was located at the entrance to the Lower Franklin Reservoir, but was later moved to the outlet with more efficient results. The two Mulholland reservoirs are treated by a chlorine station just below the Mulholland Dam.

LOS ANGELES RIVER SUPPLY

The supply from the Los Angeles River is taken from wells and galleries along and under the bed of the river



INTERIOR OF MACHINE ROOM, MULHOLLAND CHLORINATION STATION, LOS ANGELES

Chlorinators in the Center; Convertors on the Right; Scale Beams on the Left. Chlorine Cylinders Are in a Separate Room

north and east of Griffith Park. There are two systems, known as the Headworks line and the Crystal Springs line. They are treated at the river station, where they parallel each other. The Headworks line is under slight pressure and flows to Elysian Reservoir or Silver Lake Reservoir, and thence to the city. The Crystal Springs conduit is a gravity line, which flows to Buena Vista and Bellevue reservoirs. As these gravity conduits pass under the city streets, with sewers above and below, chlorination was used at the inlet to Bellevue Reservoir and the outlet from Silver Lake Reservoir to take care of seepage.

Two years ago the use of ammonia was started at the river plant, with the result that a residual of 1 lb or more per million gallons was maintained at Bellevue, Buena Vista, and Silver Lake reservoirs, and further chlorination was therefore discontinued. Treatment at the

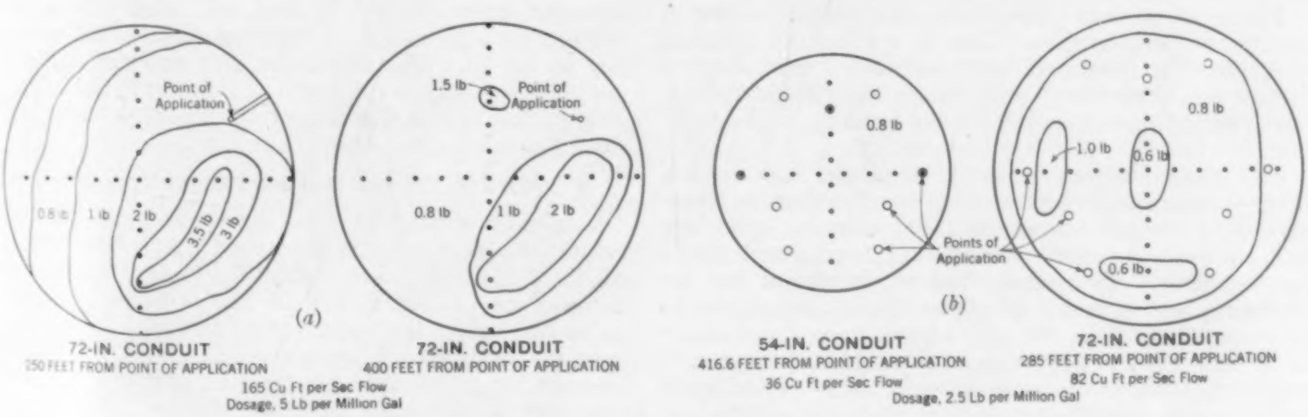
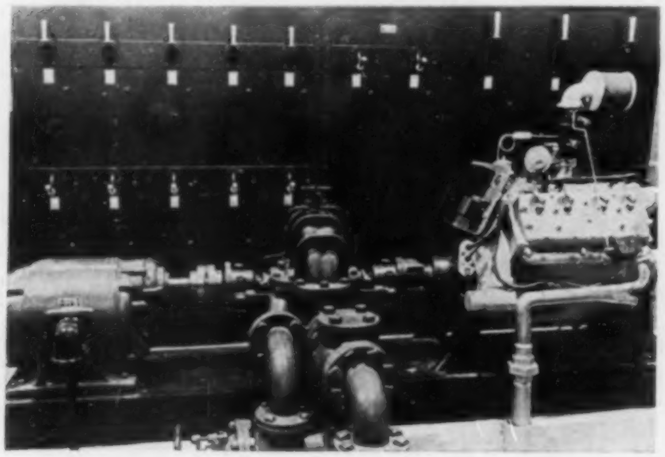


FIG. 1. RESULTS OF CHLORINE DIFFUSION TEST, SAN FERNANDO CHLORINATION STATION

(a) Single-Point Application, Showing Lack of Uniformity in Distribution; (b) Nine-Point Application Gives Satisfactorily Uniform Distribution

outlet of Silver Lake was practiced until a few years ago, because this reservoir was the center of a rapidly growing section having a large number of cesspools, with no sewers and no storm-water protection. Also, the Los Angeles River supply included some surface water. Since that time the adjacent territory has been completely sewered and the entire reservoir surrounded by a storm-water by-pass so that no surface runoff reaches it. The surface supply from the river has been discontinued and now no water is used except that filtered through the natural sands of the river bed. Chlorination was discontinued here over two years ago.



PUMP DRIVEN BY COMBINED MOTOR AND GAS ENGINE
In Case of Power Failure, the Gas Engine Furnishes an Emergency Water Supply to the Chlorinators at the Mulholland Station

An independent well supply serves the harbor district, embracing Wilmington and San Pedro. The water is high in both color and organic material, and is chlorinated and filtered at Wilmington. It is proposed in the near future to extend the aqueduct supply to the harbor, after which the wells will be used for stand-by purposes only, and the chlorination stations will be abandoned.

DEVELOPMENT OF CHLORINATION PLANTS

Chlorination was introduced in Los Angeles in 1915. At that time the buildings were little more than shacks; equipment was crude; dosages high; and complaints of taste and odor many. Since then a steady improvement has been made in buildings, equipment, and operation, with the result that complaints due to chlorine are a rarity; mechanical breakdowns seldom occur; and the stations are pleasing in appearance.

The most modern plant is the Mulholland, shown in one of the photographs. This is a two-story building of modern architecture, with separate rooms for gas cylinders, chlorinators, and pumps on the first floor, and Venturi meters and diffusion headers in the basement.

The general layout of the chlorination stations has been standardized, and control has been made automatic. A typical station includes chlorine cylinders, with a one-ton crane for moving them, and scales for weighing. Typical equipment is shown in the photographs. A drip pan is provided on the scales to catch moisture from sweating and to keep the cylinder at a more even temperature during extremely cold periods. A water-operated ejector carries waste gases to the sewer. Leads are carried from the Venturi or Pitot tube to a converter, where positive differential pressures are converted into corresponding vacuums, which in turn vary the setting of the vacuum chlorinator. In addition, an electrical device is provided to cut out one machine when its maximum or minimum capacity is exceeded and to cut in another of the proper capacity.

From the chlorinators, the solution is carried through duplicate hard-rubber lines to an injection header consisting of nine inlet pipes, as shown in one of the photographs. The injector water supplies are in triplicate so that no cessation of flow will occur if the power fails. In the case of gravity lines, such as the Chatsworth and Crystal Springs, a float-operated group of cams is used, which operate mercury pots to produce a vacuum, thereby controlling the chlorinator in the same manner as the Venturi-operated converter. The ammoniator at the river plant is operated by a float and cams similar to those for the chlorinator. In the newer stations, the chlorinators are kept separate from the pumps, gas cylinders, and other apparatus. In the older type of station, such as that at San Fernando, the tanks and chlorinators are in the same room.

Gas piping is of black iron or steel. Flexible rubber hose was originally used for solution piping but gave so much trouble from leaks and breaks that all the solution lines are now of hard-rubber piping.

ENSURING GOOD CHLORINE DISTRIBUTION

Where the chlorine solution is injected into a pipe line that is under pressure, the injecting pressure must be at least four times the main pressure. This necessitates the use of two or more electrically driven high-pressure pumps in each station. To ensure continuous performance in case of power shortages, a gasoline-driven pump has also been installed. This pump is primed and started automatically by storage batteries and relays whenever a power shutdown occurs.

Chlorine was originally applied under pressure at only one point. This led to rather inefficient mixing, and samples taken for an orthotolidin test often gave erratic results. A series of experiments were made below the San Fernando station, which showed that chlorination was inefficient and chlorine gas wasted. Pipe traverses were made and chlorine residuals plotted. The results, using a dose of 5 lb per million gallons, showed the residual to vary from zero to 3.5 lb at 250 ft from the point of application, and from 0.6 to 2.0 lb at 400 ft (Fig. 1*a*). New headers were installed, applying the chlorine at nine points instead of only one. This resulted in much more uniform mixing as shown by new traverses on both the 54-in. and 72-in. lines (Fig. 1*b*). At points 400 ft from the point of application the residual was entirely uniform at 0.8 lb per million gallons in the 54 in. line when a $2^1/_2$-lb dose was used. In the 72-in. line also, using the $2^1/_2$-lb dose, one small area gave a residual as high as 1.0 lb, and two small areas were as low as 0.6 lb. The remainder was uniform at 0.8 lb per million gallons or 0.1 ppm. The lower initial chlorine dose in this case is due largely to increased bactericidal efficiency with more uniform mixing.

QUALITY MAINTAINED BY FREQUENT TESTS

Originally a fixed chlorine dose was used, provided complaints were not too numerous. At present orthotolidin tests are taken twice daily at each station. Samples are secured at definite points below the chlorinator and before the water enters service. A curve has been plotted for each sample point, giving the time in minutes for travel of water between points of chlorination and sampling for any rate of flow. In this way the operator knows the contact period exactly, and if it is less than 20 min he waits the additional time neces-

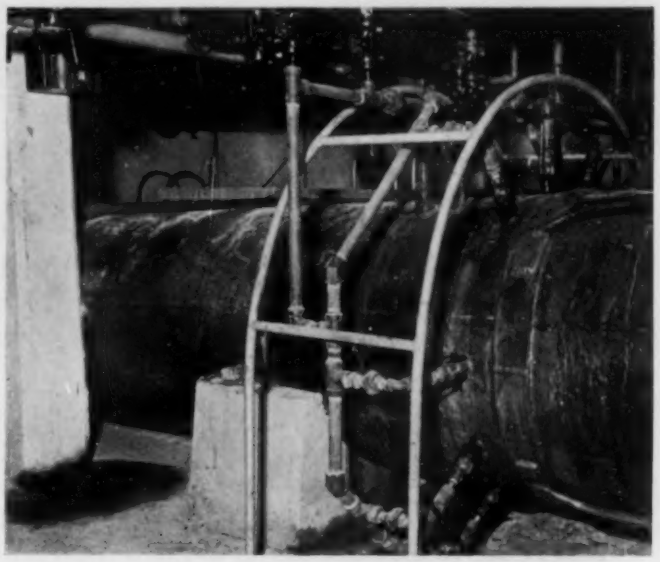
sary before reading. All readings of residual chlorine are thus for a standard time of contact. The reading is made in a standard 100-cc matched Nessler tube by comparison with orthotolidin standards, in a special cabinet against a blue light under white frosted glass. These standards and the orthotolidin solution are checked regularly in the laboratory for accuracy.

Reports giving the date, time, meter reading, rate of flow, chlorine tank weight, tank loss, intended dosage, and residual chlorine are telephoned in daily to the sanitary engineer's office. These data are recorded in duplicate in the field on standard log sheets. In addition, other field operating data, such as actual dosage, chlorine absorbed, feed rate per day as found and as set, anticipated maximum demand, main pressure and temperature, room temperature, injector pressure, turbidity of water, and machines operating, are also recorded on these log sheets. The originals are turned in to the office weekly. The data on these sheets are checked and copied on to a similar office log sheet, on which the phoned data have been placed. On this office sheet are also placed the total bacterial count on agar before and after chlorination and the B. coli index before and after treatment. There is thus a complete record of field and office data on one sheet.

Because the aqueduct water entering the local reservoirs is generally free from heavy contamination, the storage afforded by these reservoirs serves to deliver water of very low bacterial content, except during times of surface runoff. As this surface runoff occurs only during the rainy season, there is little need for chlorination at other periods. All reservoirs are fenced or well patrolled, and neither hunting on their watersheds nor fishing in them is permitted.

Bacteriological samples are taken daily throughout the year. If these show the water to be safe, chlorination is discontinued thirty days after the last rain in the spring. It is not resumed again until the fall rains produce sufficient runoff to affect the B. coli content. If the rain appears to be heavy enough to produce runoff, chlorination is started without waiting for bacteriological results. This part-time operation has resulted in a saving of some $5,000 per year in chlorine alone, and it in no way diminishes the protection given to the water supply.

During the past year, all the chlorine stations have been given complete sets of turbidity standards. Turbidity tests of the treated water are made daily, and a relationship between turbidity and the residual to be maintained is being worked out. With higher turbidities, a heavier residual must be maintained to effect the



New Nine-Point Injection Header Proves Efficient
Injector Water Supplies Are in Triplicate at Mulholland Chlorination Station to Avoid Cessation of Flow Due to Power Failure

same bactericidal action. Normal dosages range from $2^1/_4$ to $2^3/_4$ lb per million gal. Normal residuals vary from 0.6 to 0.8 lb per million gal, the lower value being used generally for turbidities of 10 ppm or less. During periods when heavy rains are likely, 0.8 lb is the residual usually maintained. At times of heavy storms, with high turbidity, a residual of 1.2 to 1.4 lb may be used.

With the use of ammonia in addition to chlorine, a residual of over 1.0 lb is maintained, even with water having a turbidity below 5 ppm. Chloramines produce much less taste than an equivalent amount of chlorine, and no complaints result.

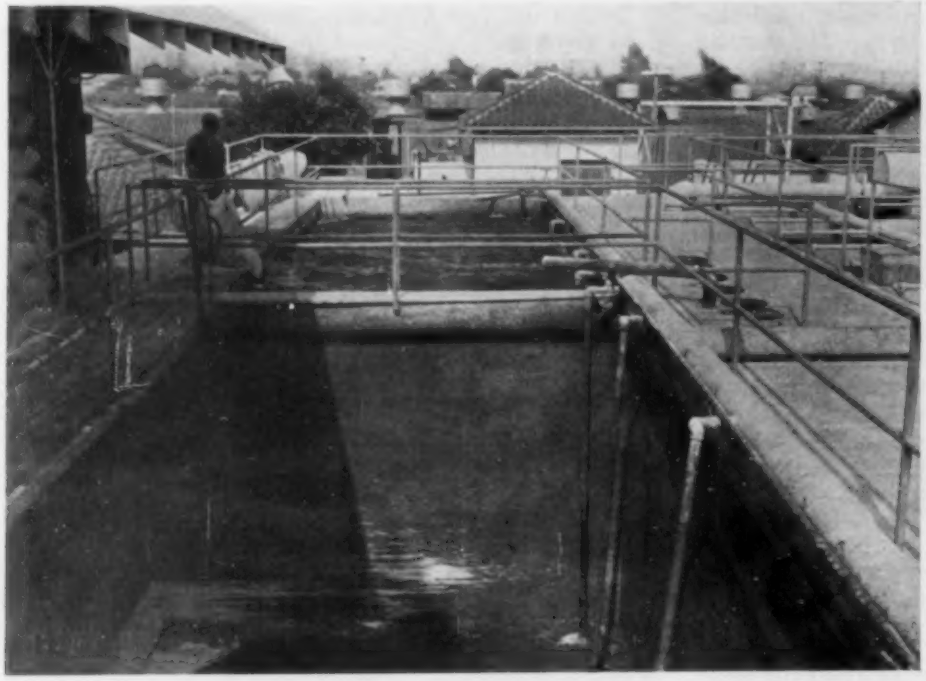
Sludge Disposal at the Pasadena Plant

By Harvey W. Hincks
Member American Society of Civil Engineers
City Engineer, Pasadena, Calif.

THREE miles southeast of Pasadena is the Pasadena Tri-City Sewage Disposal Plant, located on a 320-acre tract of land known as the Pasadena city farm. This tract is surrounded by residential sections of the adjoining cities of Alhambra, San Gabriel, and Monterey Park. An irregularly shaped parcel of land containing 29.54 acres is permanently reserved within the city farm for the operation of the plant, which is owned jointly by the cities of Pasadena, Alhambra, and South Pasadena.

The combined population of these three cities, together with San Marino, which is served by contract, is estimated at 130,000 people. Of this number 115,000, or $88^1/_2$ per cent, have their homes or places of business connected to the sewerage systems leading to the plant. The sewage contributed by the four cities enters the plant at the rate of 7,300,000 gal per day. This is equivalent to $63^1/_2$ gal per day per capita served. The flow is accurately measured by a Parshall measuring flume and registered on an automatic gage recorder. The activated sludge process for the treatment of sewage has been employed for the past $11^1/_2$ years with a high degree of success.

The treatment plant consists of fine screens, 33 aeration tanks, 6 clarifiers, 6 re-aeration tanks, and necessary appurtenances for the clarification and purification of this quantity of sewage. The average detention period in the aeration tanks is 6 hr. An average of 1.83 cu ft of air per gallon of sewage treated is used for aeration and re-aeration.



COAGULATION TANKS, PASADENA TRI-CITY SEWAGE DISPOSAL PLANT
The First Step in the Manufacture of Fertilizer Is to Coagulate the Activated Sludge

Clarifying tanks are square at the top and circular at the bottom. Each is 50 ft in diameter at the bottom, 12 ft deep at the side walls, and 16 ft deep at the center. All the tanks are equipped with spiral mechanisms, which operate at the rate of one revolution in 12 min. As the solids settle on the bottom, they are moved very slowly to an outlet in the center, 12 in. in diameter. They are then pumped, in liquid suspension, into the re-aeration tanks, from which a part of the sludge is continuously added to and mixed with the incoming raw sewage.

To prevent overloading the plant, it is necessary to remove continuously from the system an amount of sludge equivalent to the solids contained in the incoming sewage. Disposition of the excess sludge has been the principal problem connected with all sewage disposal. Pasadena has solved this problem by converting the sludge into a valuable and increasingly popular fertilizer. The excess sludge is drawn from the re-aeration tanks into two dosing tanks. Each of the latter is 33 ft long, 15 ft wide, and 12 ft deep. The capacity of the two tanks is 80,000 gal. At the present time batch dosing is used, but plans are now under way to change to a continuous dosing method, which it is expected will produce more uniform flocculation at less cost for coagulants. To coagulate the sludge, ferric chloride is added at the rate of $3^1/_2$ to 7 lb per thousand gallons, and is thoroughly mixed by aeration. After coagulation, the sludge, containing 99 per cent of moisture, flows by gravity to three vacuum filters. Filtration reduces the water content to 80 per cent.

Each filter, $11^1/_2$ ft in diameter by 14 ft long, revolves in a large tank filled with liquid sludge. The filters operate at the rate of one revolution in 6 to 12 min, depending on the density of the sludge. As the drum revolves, a sludge cake is formed on the outside, the thickness being about $^1/_8$ to $^3/_{16}$ in. At this stage it has the consistency of wet blotting paper, which it closely resembles in appearance. The filter cake is released from the drum in broken sheets, which are caught on a rubber belt conveyor on which they are carried to the drying house.

Revolving cylindrical dryers of the double-shell type are used for drying the material, one dryer being 90 in. in diameter and 60 ft long, the other 70 in. in diameter and the same length. The former is used regularly while the latter is used as an auxiliary unit. The filter cake, passing through the dryer by gravity, never comes into contact with the flame but is cascaded in the annular space between the shells, through which the hot gases are drawn from the combustion chamber. The sludge is broken into small particles by tumbling from one shell to the other on projecting irons called flights. In this process the moisture content of the sludge is re-

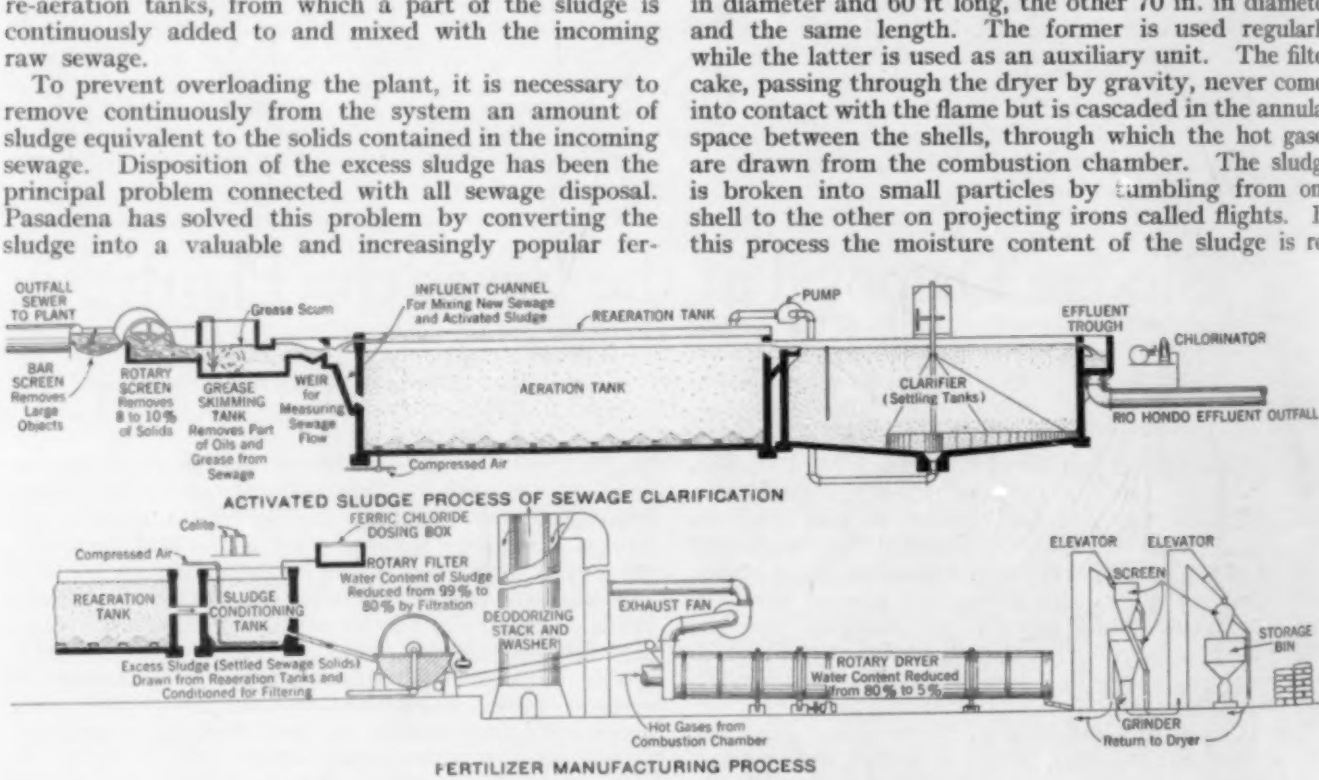
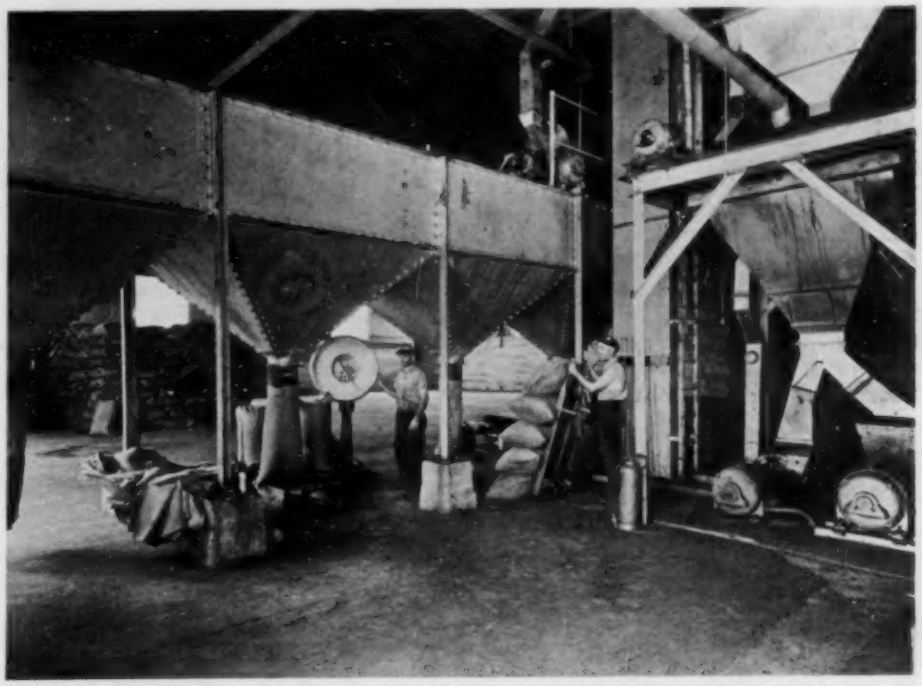


FIG. 1. GRAPHIC FLOW CHART, PASADENA TRI-CITY SEWAGE DISPOSAL PLANT
The Deodorizer or Gas Incinerator Shown Here Diagrammatically Is Illustrated in Greater Detail in the Article, "Odor-Control Experiments at Pasadena," by O. H. Hedrich

duced from 80 to 5 per cent. Natural gas is used as fuel for the drying process. The temperature in the dryer ranges from between 1,000 F and 1,500 F in the inner shell next to the combustion chamber, to between 400 F and 500 F in the outer shell at the discharge end. The hot gases pass through two passes of the dryer and discharge at the rate of 15,000 cu ft per min at 200 F.

In this connection it is interesting to know that all pathogenic germs are destroyed. A recent analysis made of samples of fertilizer prior to processing and after drying, using the standard method of bacterial count of viable organisms per gram, revealed that there was a count of 8,200,000 per gram in the unheated filter cake, while the count was only 30 per gram in the finished product after drying. In a sample of sun-dried sewage sludge a count of 15,600,000 per gram was found.



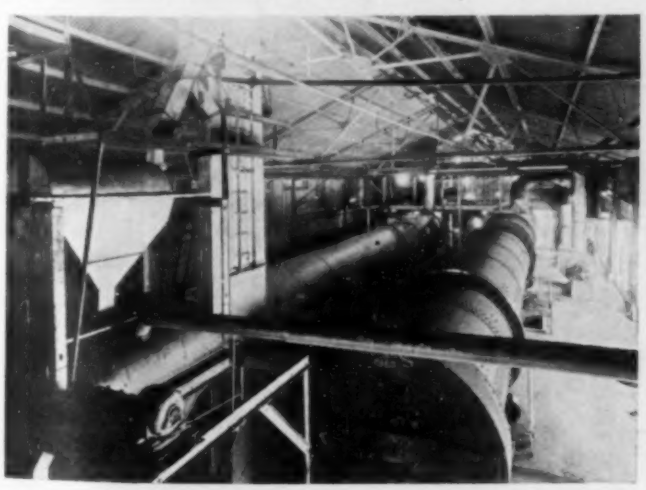
GRINDING, SACKING, AND WEIGHING FERTILIZER, PASADENA
The Dried Fertilizer Is Ground, Screened, and Packed in 100-Lb Burlap Sacks

On leaving the discharge end of the dryer, the dried fertilizer passes through screens to grinders and then through another stage of screening, during which the over-size ground particles are rejected, so that only those of proper size are allowed to enter the storage bins. It is then packed in burlap sacks each containing 100 lb net weight. The sacked fertilizer is stacked in uniform piles of 20 tons each, with aisles between each pile. A portable elevator is used not only for stacking but for loading the trucks for delivery. A set of scales is provided at the loading platform to check the total weight of fertilizer as loaded.

The production of fertilizer for the calendar year 1934 amounted to 3,034 tons. This is an average of 1.14 tons per million gal of sewage treated, or nearly 53 lb of fertilizer per year per unit of population served.

MARKETING OF FERTILIZER

During the first two years that the plant was in operation various methods were used to dispose of the sludge, none of which were satisfactory. It was found impracticable to run liquid sludge either on to the city farm orchards for fertilization purposes or into lagoons for settling, on account of the fly and odor nuisance. Next to be tried was burying the sludge in the ground after filtering, but the expense proved to be enormous.



REVOLVING CYLINDRICAL SLUDGE DRYERS, PASADENA
These Dryers Reduce the Moisture Content of the Sludge from 80 to 5 Per Cent

In 1926 a dryer was purchased and installation completed by February 1927. About the first of January 1928, the disposal plant was ready to market its product under the coined name of "Nitroganic," which was made up from the words, "nitrogen" and "organic." For several years there was a decided prejudice against the use of sludge as a fertilizer, owing to its origin. Fortunately this prejudice has been overcome—to the extent that for the past two years the demand has exceeded the supply.

Prior to three years ago the product was sold partly through dealers and partly direct from the plant. The results were unsatisfactory; the dealers were dissatisfied; and large inventories became a burden. Three years ago it was decided to sell only through certain contract distributors, who would be required to sign yearly agreements that they would purchase and take delivery of a certain minimum tonnage within the 12 months' period. They were also required to agree to maintain such selling prices as might from time to time be established by the City of Pasadena. A discount from the established selling price is allowed the distributor large enough to enable him to pay a salesman's commission or to sell to a sub-dealer for re-sale.

This plan has proved to be very satisfactory and successful. The product is being sold by sub-dealers in San Diego on the south and Santa Barbara on the north as well as in 11 cities adjacent to Pasadena. The larger part of the product is sold by the distributors to citrus ranchers in Los Angeles and Orange counties. Nitroganic is being applied to orange groves by means of a special end-gate spreader. The best method of applying it to lawns and golf courses is by means of a hand-propelled spreader.

The principal characteristic of Nitroganic which

distinguishes it from inorganic ammoniates is its slow rate of decomposition. The nitrogen in most inorganic fertilizers becomes available to the plant as soon as the material is applied and absorbed by the moisture of the soil. Consequently the plant food is consumed completely or lost within a few weeks after application. Nitroganic, on the other hand, supplies a good, slow-acting form of nitrogen, which continues to be available long after the other forms of nitrogen have been exhausted.

Nitroganic is in effect a "predigested" fertilizer, containing in addition to the ordinary plant foods, such as nitrogen, phosphoric acid, and potash, an exceptionally wide range of secondary plant foods and rare elements. In fact it is very rich in these other essential ingredients, which are further supplemented by an unusually liberal organic content. Its ratio of organic matter is considerably higher than that in most fertilizers. A distinct advantage of Nitroganic over animal manures and sun-dried or bed-dried sludge is that it contains no foreign substance, no weed seeds, and no pathogenic, or disease-causing, organisms of any kind. Nitroganic contains a greater amount of plant food, more organic matter, and less moisture.

In conclusion it might be interesting to state that the change in the method of sludge disposal from filtering and burying in ditches to filtering and manufacturing of fertilizer, has resulted in a net saving varying from \$22,000 to \$40,000 per annum, the variation being governed by the market price of the fertilizer.

Odor-Control Experiments at Pasadena

By O. H. HEDRICH

MECHANICAL ENGINEER, CITY OF PASADENA, CALIFORNIA

EARLY in 1927 the sludge-drying equipment at the Pasadena Tri-City Sewage Disposal Plant was constructed and placed in operation. From the beginning, difficulty was experienced with the odor in the exhaust gases from the dryer. Twelve or fifteen different ideas were tried out in attempts to eliminate this nuisance.

The original attempt at odor removal consisted of passing the dryer exhaust gases through a series of water sprays located near the top of a concrete tank about 8 ft in diameter and 7 ft high. The discharge from the tank passed out at the top, through a short stack of vitrified tile 10 ft long and 24 in. in diameter, the bottom 2 or 3 ft of which was filled with cracked lime rock continuously wetted by an overhead spray. The gases were then discharged into the atmosphere. A very short trial period indicated that practically none of the odor was being removed.

This apparatus was then modified to include a charcoal bed filter, and approximately 100 lb of chlorine per day was introduced into the outgoing gases. Practically no improvement was noticed. At this time complaints were coming in from the surrounding neighborhood and from points as far distant as two miles.

The idea was then conceived that if the gases were sufficiently cooled by passing them through a long run of pipe equipped with sprays, the objectionable odor might be condensed. Accordingly the dryer gases were led through approximately 200 ft of 24-in. steel pipe, equipped with water sprays located 10 ft apart, and were finally discharged into the incoming sewer line upstream from the screen house. This attempt resulted in the discharge of a large part of the gas into the screen house and the remainder through manholes along the outfall sewer, but no reduction in odor was apparent and the idea was abandoned.

The next attempt consisted in discharging the dryer gases into the effluent outlet, a 36-in concrete line leading into the Rio Hondo stream bed at a rather isolated section four miles below the plant. Objectionable gases soon became evident, however, and complaints continued.

OZONE AND CHEMICAL DEODORANTS PROVE INEFFECTIVE

Oxidation of the gases by means of ozone was then suggested, and an ozone generator was installed which injected 12 g (6.8 cu ft) of ozone per hour into the fan exhaust line leading to the effluent outfall. At this time the volume of the gases issuing from the dryer was approximately 7,000 cu ft per min. While some improvement was noted, complaints continued to come in. Another ozone generator, having an output of 20 g (11.3 cu ft) per hr was installed on a trial basis. With both generators in use, a total of 32 g (18.1 cu ft) of ozone per hour was injected into the exhaust gases. This experiment proved very discouraging, as

APPLYING FERTILIZER TO AN ORANGE GROVE

"Nitroganic," Product of Pasadena Tri-City Sewage Disposal Plant, Being Applied by Means of Special End-Gate Spreader

the gases were discharged at the Rio Hondo outlet without any apparent loss in volume or sufficient reduction in odor. Chlorine introduced in addition to the ozone made no appreciable improvement.

A spray washer was then installed in the fan exhaust line to wash the gases before they entered the effluent outfall line, and in spite of continued protests it was necessary to use this method of treating the exhaust gases while further study of the problem was going on.

A patented chemical deodorant which had been used with spectacular success in the treatment of animal carcasses after the San Francisquito Dam disaster was next utilized. The dryer exhaust gases were passed through a bath of it, but as in all previous attempts, without removing the odor appreciably.

In accordance with the instructions of the State Board of Health, which ordered that the drying plant be closed until some satisfactory means of odor elimination should be worked out, the dryers were shut down from September 29 to November 10, 1927. During that period the sludge was buried in trenches, but this method brought its own odor problem due to the putrefaction and gasification which occurred.

OXIDATION AT HIGH TEMPERATURES

The next attempt at deodorization was based on the theory of high-temperature oxidation, which held that a considerable amount of heat would act as a catalytic agent to cause a combination of the oxygen in the air and the odorous constituents of the stack gases. A very small experimental furnace was built, fired with an acetylene welding torch. By passing dryer gases through this furnace, it was found that a stack temperature of about 1,000 F results in complete oxidation of gases and elimination of odors. With the volume of the gases known, it was a simple matter to design a furnace that would heat the gases to the proper temperature, and to determine the approximate cost of the fuel required. Computation showed this method of odor elimination to be quite expensive from the standpoint of fuel cost, but inasmuch as the State Health Department would not permit use of the drying plant without deodorization of the dryer gases, it was decided to build a gas incinerator furnace. This was done, and the furnace was put in operation November 10, 1927.

The horizontal furnace was of rectangular brick construction, surrounded by a steel casing and provided with baffles so that the incoming gas could be preheated by spiral circulation around the furnace. A 500-hp Peabody combination gas or fuel-oil burner was used. At first the dryer gases were passed through the central opening of the burner, but the velocity through the *vena contracta* was such as to extinguish the flame, and it then became necessary to provide ports through the front wall as a means of entrance for most of the gases. Some gases were allowed to pass through the burner, thus providing air for combustion of the fuel.

In general, this furnace was successful as long as the stack temperature was maintained at 1,000 F or over, but some difficulties were experienced due to the combustion of quantities of sludge dust, which was carried into the preheating jacket with the dryer gases. Minor explosions occurred, and it was necessary continually to clean out the gas passages surrounding the furnace. In general, while the operating cost of the furnace was high, the results attained as far as deodorization was concerned were quite satisfactory. This was evidenced by the decrease in complaints.

After the horizontal furnace had been in operation approximately 12 months, it became necessary to install a second and larger deodorizing furnace, because of occasional shutdowns to make repairs.

GAS INCINERATING FURNACE CONSTRUCTED

On account of the difficulties experienced with the horizontal furnace, it was decided to build a vertical type with auxiliary air to aid combustion. It was believed that this type would have the following advantages: no stack would be required; less ground space would be necessary; sludge dust could be more easily removed; better control of furnace temperature

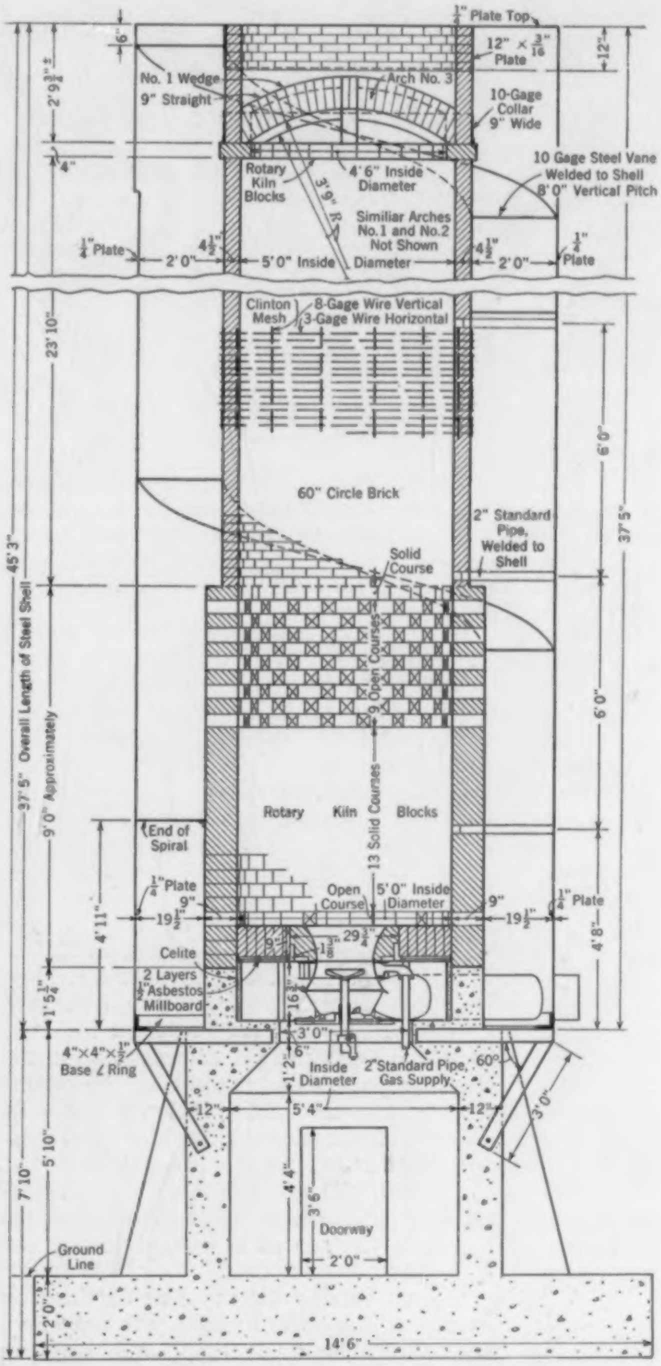
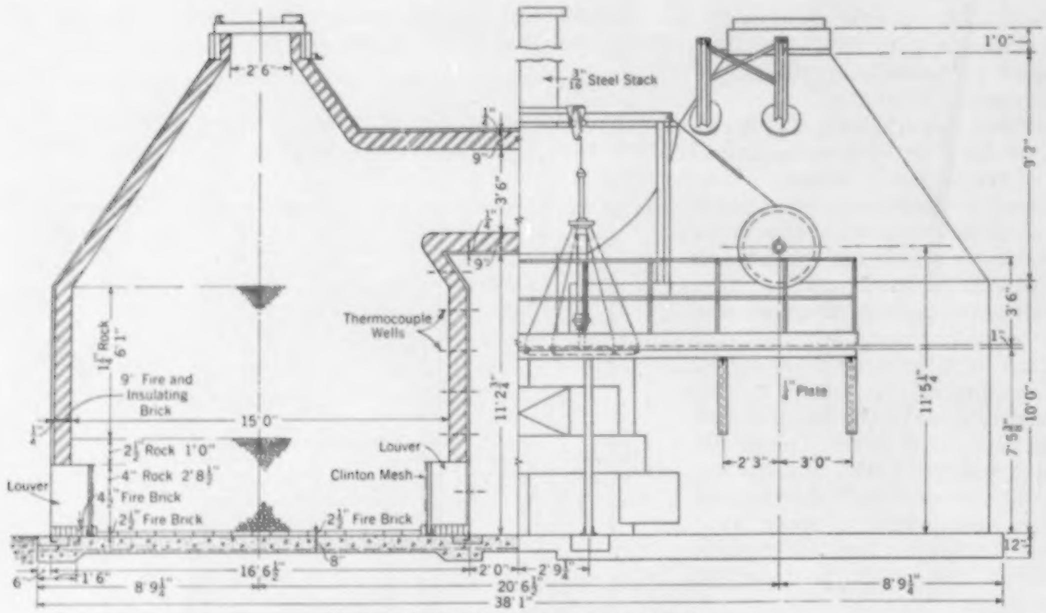


Fig. 1. Gas Incinerator, Pasadena Tri-City Disposal Plant

Dryer Gases Enter the Spiral Preheating Jacket near the Top and Travel Downward to the Ports in the Lower Section. This Deodorizing Furnace Operated Successfully at Stack Temperatures Above 1,000 F, but the High Fuel Consumption Led to Plans for the Combined Deodorizer and Heat Exchanger Shown in Fig. 2



LONGITUDINAL SECTIONAL ELEVATION

FIG. 2. PROPOSED DE-STENCHER FOR PASADENA DISPOSAL PLANT
Consisting of Two Steel Wells 17 Ft in Diameter Enclosing Brick-Lined Deodorizing Furnaces and Connected by Reversing Valves for Heat Exchange

would be possible; and the difficulty of the flame being blown out would be eliminated.

Accordingly, the vertical deodorizing furnace shown in Fig. 1 was installed in the fall of 1929. The dryer gases enter a spiral preheating jacket near the top of the shell and travel downward to a series of ports in the side walls a short distance above the burner. Experience has shown that there are certain disadvantages in this type of furnace, however. For one thing, the sludge dust in the gases accumulated on the baffle vanes to such an extent that it became necessary to completely remove them and allow the gases to pass vertically downward through the jacket. It was also apparent at times that the gases to be deodorized were not in contact long enough with the gases of combustion.

In general, it can be said that this furnace has been quite successful. This is evident from the fact that complaints from odor nuisance have not been frequent and that the area affected by slight occasional odors is very small. The one great disadvantage in the operation of this furnace is the cost of the fuel required. In order to give an idea of the amount, for the fiscal year of 1933–1934 the fuel for drying cost $7,360, and that for deodorizing, $7,200. Thus, with this type of furnace, approximately the same amount of fuel is necessary to deodorize the gas as is needed to dry the wet sludge.

Up to June 1934, no further attempts at deodorizing were made. However, since the furnace was not effective all the time and occasional complaints were received, and also because the operating cost was very high, a further effort was made toward finding some more efficient means of deodorizing. Some computations were made with the idea of using a heat exchanger to recover the waste heat and reduce the fuel bill, but the temperatures involved and the cost of the apparatus seemed at first to make its use impracticable.

EXPERIMENTS WITH HEAT EXCHANGER AND WITH CHEMICAL DEODORIZER

At this time some experiments were being carried out at the University of California, at the suggestion of Dr. F. G. Cottrell, with a type of heat-exchanger developed by P. H. Royster. The work was carried on under the direction of Charles Gilman Hyde, M. Am. Soc. C.E. The test apparatus consisted essentially of a vertical steel cylindrical housing enclosing two refractory beds located one above the other, with a combustion space between the beds and with piping so arranged that incoming gas might be passed through the two beds alternately upward and downward.

In operation, the burner is lighted and one bed heated to a desired temperature. The amount of fuel burned is then reduced to that necessary to overcome radiation plus the slight loss which is evidenced by the higher temperature of the exhaust gas. This results in the incoming gas being heated to a temperature very closely approaching that of the heated refractory in the hot bed and then passing through the cold bed, giving up its heat and discharging into the atmosphere close to the entrance temperature. As soon as the exit temperature starts to rise, the flow is reversed and the heat driven back to the bed from which it originated. In this way, it is possible continuously to heat the gas to the oxidation temperature desired and subsequently cool it so as to recover practically all the heat.

Upon conclusion of the experiments at the University of California, the apparatus was moved to the Pasadena Tri-City Sewage Disposal Plant, and a series of tests were run with dryer exhaust gas. The results obtained were so satisfactory, in so far as heat consumption and deodorization were concerned, that it was decided to build a full-scale unit to handle the entire amount of dryer gas, which at the present time approximates 15,000 cu ft per min at 200 F. While the drawings for the full-scale apparatus were being made, a series of experiments with a cyclone type of dust collector was carried out to prevent the clogging of the refractory beds by sludge dust. A multiple-unit cyclone collector was found unsatisfactory for this purpose, as, because of the high humidity of the gases, the sludge dust would collect on the sides of the cyclone tubes and stop up the lower end through which it was supposed to drop.

It was then decided that the only practicable method was to build two spray towers. These towers were put in operation in the early part of June 1935, and have proved eminently successful. Approximately 150 gal per min of effluent water is pumped through 27 spray nozzles in the two towers, and while no definite figures are at hand, it is believed that at least 90 per cent of the dust is washed out of the gases.

Coincident with the installation of the spray towers, another idea for deodorization of the gases was proposed to the city by Francis Stewart, formerly of the DuPont Corporation. Mr. Stewart's apparatus consists of a cylindrical tank containing a quantity of sodium hydrox-

ide, through which the gas to be deodorized is passed. A perforated bubble plate serves to break up the gas and bring it into close contact with the solution.

A full-scale Stewart machine was built and was placed in operation in June 1935. Approximately six weeks of experimentation showed that while a considerable part of the odor was removed, the results were not complete enough to permit of adopting the idea permanently, and it was decided to proceed with the immediate installation of a pair of Royster heat-exchanger stoves.

FULL-SCALE HEAT-EXCHANGER APPARATUS IN PROCESS OF ERECTION

As laid out at the present time, the Royster apparatus will consist of two cylindrical shells, approximately 17 ft in diameter, lined with $4^1/_2$ in. of insulating brick and $4^1/_2$ in. of refractory material, and provided with suitable water-sealed reversing valves for directing the flow of gases back and forth through the fuel beds to the atmosphere (Fig. 2). Each stove will contain approximately 90 tons of a type of natural rock which experiments have shown will successfully withstand a temperature of 1,600 F. It is planned to operate the stoves so as to give a hot-zone temperature of 1,100 F, and it is estimated that the temperature of the outgoing gas will be between 150 and 200 F, depending on the temperature of the incoming gas, which will be about 90 F, owing to the cooling effect in the spray towers.

As this paper is printed, the full-scale stoves are being erected and will be ready for operation some time in October. It is confidently expected that these stoves will thoroughly deodorize the dryer gases at a fuel cost of not more than 15 per cent of that required in the present gas incinerating furnace.

Disposal of Refuse at Sea

By WALTER N. FRICKSTAD, M. AM. SOC. C.E.
SUPERINTENDENT OF STREETS, OAKLAND, CALIF., AND EX-OFFICIO CITY ENGINEER
and R. R. RIBAL, ASSOC. M. AM. SOC. C.E.
DESIGNING DRAFTSMAN, ENGINEERING DEPARTMENT, OAKLAND, CALIF.

OAKLAND, Calif., is the only large city disposing of its refuse solely at sea. After 17 years of experience, and with a contract that does not expire until 1944, the city believes that it has a satisfactory solution of its disposal problem and plans no change.

Mention of the collection system is necessary, for the cost of disposal is largely derived from the collection service charge. Three contracts—refuse collection, "wet garbage" collection, and refuse disposal—have within the last six years been consolidated into one, held by a mutual organization of original scavengers who have the exclusive privilege and duty of removing all refuse at rates established by city ordinance.

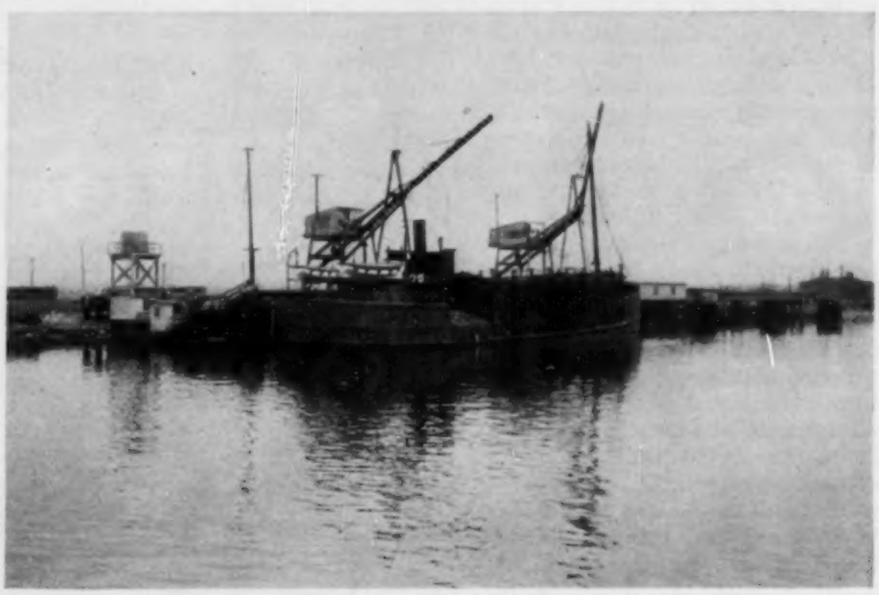
Under the contract for collection of refuse, the maximum base rates are 50 cents per month for one collection per week of 30 gal or less, or 75 cents per month for biweekly collections. Producers of larger quantities are charged one dollar per cubic yard.

"Wet garbage"—kitchen or table refuse from the preparation of food—is fed to hogs. The scavenger collects it without charge and pays the city a base rate of one dollar per ton when the average monthly price of hogs is 5 cents per pound, and 10 cents per ton addition for each one-half cent increase in the price of hogs.

HISTORY OF DISPOSAL SYSTEM

The system of disposal at sea was begun in May 1908, because of the failure of a privately owned incinerator to operate satisfactorily, and of the inadvisability of dumping on land and attracting rats at the time of the bubonic-plague threat of 1907. A one-year contract was let for the operation of a steam lumber schooner, the deck of which was equipped with bunkers having a capacity of 395 tons each.

The ship was loaded by dumping directly into the bunkers from a ramp wharf. The first unloading place was approximately 10 miles from the mainland near the San Francisco Light Vessel. Following complaints that refuse was being cast on the beaches, the unloading operations were moved to a location 20 miles from the nearest mainland. In 1911, the 20-mile distance was established as the minimum by act of the legislature. Early in 1915, however, new complaints caused the voluntary change to a point 6 miles farther southwest in 300 fathoms of water and 25 miles from the nearest mainland.



A GARBAGE STEAMER USED BY THE CITY OF OAKLAND FOR DISPOSAL OF REFUSE AT SEA

During a heavy storm in January 1916, the ship foundered on the bar and was lost with the entire crew, and for a while, thereafter, refuse was dumped as fill on western waterfront tidelands. The resulting complaints from residents and federal health authorities brought about the resumption of disposal at sea in October 1925.

CLEANING THE WHARF DURING LOADING
The Metal Plates Are the Back Aprons of the Buckets Into Which the Trucks Dump

FIRE HOSES CLEAN THE REFUSE SHIPS AFTER DUMPING
Sanitary Conditions Are Also Maintained at the Wharf by a Thorough Daily Washing

Two ships, with cargo capacities of approximately 535 tons and 550 tons, respectively, were then provided. These alternate in service, one being loaded while the other is making a trip to sea, and provide adequate capacity in case of fog or storm delay. Each ship has eight bunkers, four on a side. Large top-hinged doors, opened and closed by an ingenious arrangement of cables and latches from inside the ship, comprise the water side of the bunkers.

The refuse is loaded by dumping from trucks over the edge of the wharf into bottom-discharge buckets of 5-cu yd capacity, which rest on stringers near high-tide level. The buckets are then hoisted by a traveling crane to a suitable position over the ship and dumped. During loading the wharf is cleaned continuously, and it is given an additional washing at the close of each day. The ships are thoroughly washed with fire streams immediately after unloading.

Full records of early costs are not available. In 1913—the median year of the first period of disposal at sea—the gross cost for the disposal of over 50,000 tons was $37,070, of which the collectors contributed $12,000 as franchise fees. The income to the city from the wet-garbage collection contract was $12,000.

The first two years of the period of disposal by dumping as fill (1916–1925) provided a small revenue but by 1925, despite increased income, the net cost to the city was $25,000.

Upon the resumption of disposal at sea in 1925, the contract price was 87 cents per ton. Adding loading and other charges, the gross cost was $1.22 per ton, or $93,667 for 76,675 tons hauled during the first complete fiscal year of 1926–1927. Operating economies and a reduction of disposal contract price to 65 cents per ton in 1931 reduced the gross cost to $0.845 per ton in the year 1931–1932, or $67,329 for 79,622 tons. A part of the foregoing costs was covered by contributions from the collectors and neighboring cities, amounting to $26,878 in 1926–1927 and $54,391 in 1931–1932. In 1932 the disposal contract and both the collection contracts were consolidated; franchise fees were eliminated, except as to wet garbage; and the contractor no longer received the per ton rate for transporting refuse to sea. The city still pays for inspection, watchman service, and loading-equipment maintenance, which is approximately balanced by contributions from two neighboring cities and revenue from wet garbage.

TRANSFERRING REFUSE FROM DUMP-BUCKETS TO DISPOSAL SHIP

Littering of adjacent shorelines with refuse is a special nuisance that often limits or prohibits disposal at sea. All complaints are carefully investigated, many in cooperation with the State Department of Health. As a result of the latest and most complete investigation, which was made between November 1931 and October 1933, the following conclusions were reached:

1. Refuse is constantly fed to beaches from ships and water-front industries in San Francisco Bay.
2. In proportion to the total refuse, the refuse from the Oakland ships is insignificant, except under unusual wind conditions which occur but few times in some years and, in other years, not at all.
3. Refuse, traceable to the garbage ships, generally appears on unfrequented beaches distant from the harbor entrance, is generally non-putrefactive, and disappears rapidly from the beaches.
4. Beaches should be cleaned promptly by the City of Oakland when refuse is reasonably traceable to its ships.

Thus it may be stated in conclusion that Oakland has an efficient and economical method of refuse disposal; that the ocean currents and prevailing winds at the dumping ground are favorable to the purpose; and that the ship capacity and favorable weather conditions offshore ensure disposal at sea without serious interruption.

Water-Conduit Construction in the West

Modern Materials and Construction Methods That Increase Capacity

By Fred C. Scobey

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NEW materials and adaptations of old materials for use in water conduits are here discussed largely from the standpoint of the irrigation engineer. Both open and closed conduits are considered, with special emphasis on methods employed to increase flow capacity. Design values of Kutter's "n" are suggested for various surfaces. The present article is an abstract of the illustrated address given by Mr. Scobey on July 4, 1935, before the Irrigation Division at the Annual Convention of the Society in Los Angeles.

SINCE the beginning of the century the number of new materials and adaptations of old materials utilized for water conduits has increased many fold. It was not many years ago that even the best canals were unlined; flumes were largely rectangular box structures of surfaced or plain lumber; pipes for irrigation were of "cement" or riveted metal, or occasionally were wood-stave lines of redwood or untreated fir. This list contrasts strikingly with the great variety of materials that are available today.

In the past few years the trend has been toward extending the life and increasing the capacity of water conduits—particularly the latter. The engineering profession has become acutely aware of the great difference in capacity between surfaces of different materials and between surfaces of a given material developed under different processes of construction.

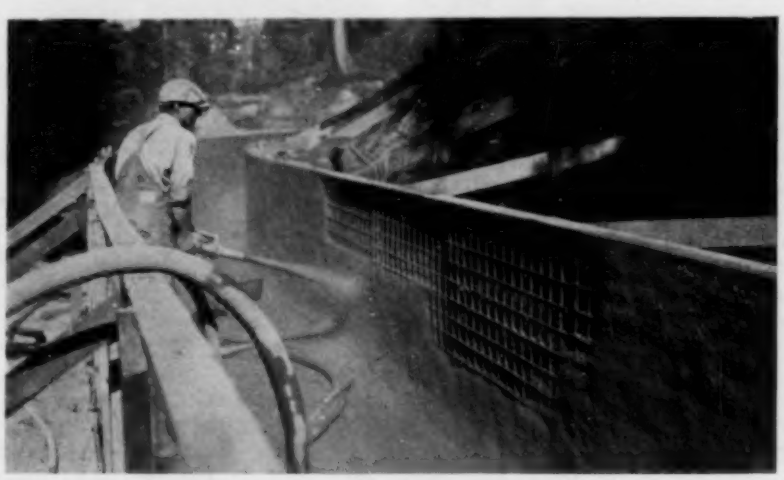
One of the outstanding examples is the reconstructed parts of the Owens River Aqueduct serving the city of Los Angeles. Originally designed to carry 430 cu ft per sec, after 20 years of operation it had a maximum capacity of only some 400 cu ft per sec. When investigations regarding a possible additional supply from Mono Lake drainage were started, it became evident that it would be necessary either to build a new conduit or to increase the capacity of the old one. The latter scheme was adopted, and although the old conduit was actually made smaller in size by the laying of a new and very smooth bottom, it has since carried 500 cu ft per sec. This increase of 25 per cent in capacity was attained at less than 3 per cent of the cost of the original aqueduct.

Distribution systems for irrigation are largely in open country. Initial construction of larger canals is mostly in unlined earth excavation. A value of 0.0225 for n in the Kutter formula is generally used, although 0.020 is suitable for large canals that will be well maintained and 0.025 for small canals that may not receive much care.

Many canals for irrigation and hydroelectric development located in hilly and mountainous terrain, particularly in canyons, are wholly or partly excavated in rock. This is especially true of the uphill bank; the lower is usually partly in earth excavation and partly formed with the rocky debris resulting from the cut on the upper side. As a demand for greater capacity arises, such a canal is improved by lining either the whole section or the lower bank with paneled or gunite concrete, or with concrete slabs. Sometimes additional capacity is secured by building up a thin, hand-laid wall of rock debris on the downhill side, and binding it together with gunite shot on the inside. If the excavation is particularly rough, because of the way the rock breaks, it may be improved by chinking the holes and still further bettered, if necessary, by shooting the rubble surface with gunite. Where the whole prism is in rock cut, values of n from 0.035 to 0.045 are used. A relatively smooth earth-and-rock fill on the downhill side takes a value around 0.030. Where the excavation is in rounded river gravel and cobbles, a value of about 0.027 is correct. Rock cuts on the upper side and concrete lining on the lower bank show values of n around 0.025. Gunite may be used immediately after excavation to improve the surface and to prevent weathering of rock cuts.

METHODS OF CONSTRUCTING CONCRETE LININGS

Concrete is the predominating material for the lining of earth canals. Usual practice calls for poured flat panels forming a trapezoidal section. Some form of expansion joint is generally provided between panels. The value of Kutter's n most frequently used for concrete linings is 0.014. To the writer this value separates surfaces of smooth texture from the rough ones. Any value of n less than this calls for a surface better than the average, especially for flat panel work. Curved surfaces, such as those shown in the views here included, can be made to attain a value of 0.013, either in poured or gunite work. The use of such low values in design depends on the silt and algal accumulation that may be expected. In many locations insect larvae go through the first two or three stages of their four-stage existence in the water. In either the



Cross-Over Flume, near Emigrant Gap, California
Of Gunite, Shot from the Inside and Trowel Finished. Note the Characteristic Rough Surface Previous to Troweling

larval or the pupal stage, they often accumulate in such quantities as to seriously reduce the canal capacity. If these factors are anticipated, a value of n of 0.015 is not too conservative. Smooth surfaces are usually desirable, in order to ensure maximum capacity.

Occasionally canals in earth or rock debris are lined after a period of service, to reduce seepage, and a canal so

OUTLET END OF A MODERN METAL FLUME

The Refugio Flume of the Borel Conduit, Southern California Edison Company, Approximates in Section the Hydrostatic Catenary and Has Steel Cross Bars and Countersunk Joint-Rods

finished, no matter what the lining, has a capacity in excess of the original. In such cases little or no attention may be paid to the roughness of the lining. In fact, the tightest lining, and also the roughest, is probably unsmoothed gunite. The values of Kutter's n run from 0.017 to 0.018 or more for such a finish. A canal so treated should not be condemned on sight merely because of the excessive roughness of the lined surface; the capacity may still be higher than is required. Heavily silt-laden water is a great evener of surfaces, tending to fit smooth and rough alike to a common coefficient.

A method of lining the lower bank in mountain canals, with a minimum of time wasted, is to precast concrete planks, distribute them along the canal, and then turn out the water for a few days and set the planks running up and down the slope. Such a lining is intended rather to prevent bank erosion and increase capacity than to reduce seepage. Lumber also has been used in this way.

Where labor is cheap and concrete materials costly, some canal linings have been constructed by laying rubble walls and grouting the inside with concrete mortar. Mexican laborers are particularly well fitted for such work, as they are adept in the handling of adobe mud and hence in concrete mortar and masonry.

Linings in canals that are set below the natural water table must be protected against collapse resulting from bank-water pressure. This is particularly true if the canals are to be unwatered from time to time. Instances of such collapse are known to nearly all canal operators. The protection may be obtained in several ways: by draining the adjacent right of way; by arch action effected by curving the side panels and strutting the top edges; or by flat panels similarly strutted, with the bottom dished to develop arch action and prevent buckling inwards.

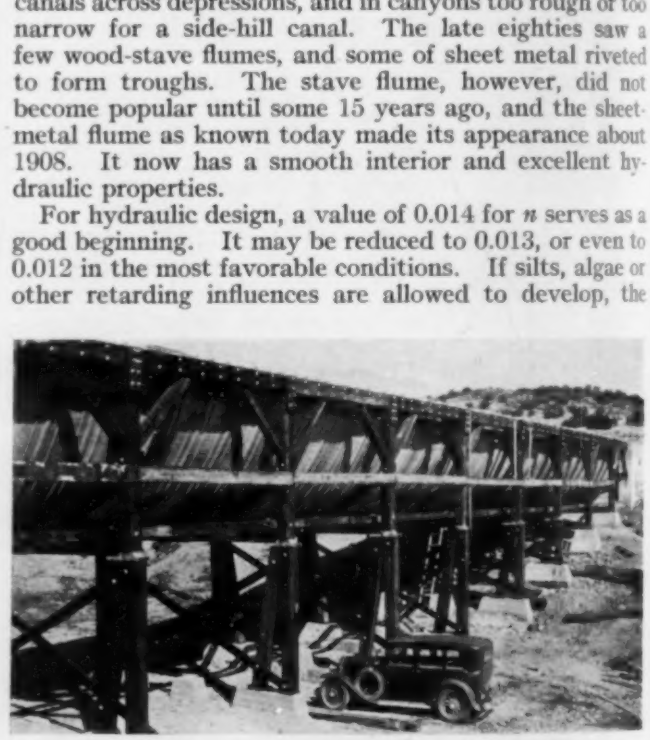
Some canals in sandy soils are lined with metal fluming, or with wood-stave pipe flowing partly full. For all such light-weight linings, care must be taken to prevent failure resulting from floating the structure like a boat. Floating is sometimes caused by rain water finding its way under the lining and sometimes by leaks in the structure itself. It can be prevented by draining off outside water, by anchoring the structure every few feet by means of wires tied to "deadmen," or by weighting it with rocks on the foot plank.

MODERN IMPROVEMENTS IN FLUMES AND TUNNELS

Masonry flumes with natural cement linings formed the great Roman aqueducts, and the idea was later carried to France, Spain, and Mexico. Usually they brought water to large cities for domestic purposes. The reinforced concrete flume is a development of the twentieth century. It can be made in many different ways, each producing a characteristic interior surface and a carrying capacity likewise its own. It may be poured in place in panels from 10 to 20 ft long, with expansion joints between them. Gunite has been shot from the outside against smooth wooden forms in making the sides, and directly against the subgrade of bench flumes, in constructing the floor. The inner surface of side walls so shot needs no further treatment, but the floor can be much improved by the use of a trowel or other smoothing device. Gunite shot from the inside produces a rough interior unless it is subsequently smoothed. This type of construction is shown in one of the accompanying illustrations. The surface (trowel-finished) yielded a value of n of 0.0135. The concrete flume is usually of rectangular form, but has been built in circular shape in both poured forms and pre-cast units, and has also been poured in the form of the hydrostatic catenary, thus eliminating all bending moment and shear in the reinforcing steel under full load.

During the early years of irrigation in this country, the wooden box flume was generally used in carrying canals across depressions, and in canyons too rough or too narrow for a side-hill canal. The late eighties saw a few wood-stave flumes, and some of sheet metal riveted to form troughs. The stave flume, however, did not become popular until some 15 years ago, and the sheet-metal flume as known today made its appearance about 1908. It now has a smooth interior and excellent hydraulic properties.

For hydraulic design, a value of 0.014 for n serves as a good beginning. It may be reduced to 0.013, or even to 0.012 in the most favorable conditions. If silts, algae or other retarding influences are allowed to develop, the



EXTERIOR OF REFUGIO FLUME

value of n may increase to 0.016, 0.017, or more. The common short flume of, say, less than 1,000 ft in length, can draw help from the canal upstream by "heading up" or "afflux"; it can therefore be built and successfully operated with less conservative values of n than can a long flume, which must rely on its own size and slope for its capacity.

Tunnels are operated sometimes as pressure conduits and sometimes as open channels. Where the rock excavation is lined in only a few spots, a value of 0.035 for n has been found quite satisfactory. This value is based on the design section for both area and wetted perimeter. Modern lining shot with a concrete gun yields surfaces comparing favorably with well-made concrete pipe, the value of n being 0.012 or less for circular sections. For horseshoe or other shapes, a value of 0.013 for n requires a bottom surface smoother than is attained in most construction. Linings placed less carefully will not yield surfaces corresponding to a better value of n than 0.014 or 0.015.

Circular conduits are used in three general ways in irrigation and hydro-electric development:

1. As "flow" lines under little pressure at maximum capacity, or under no pressure (acting as flumes) most of the time.

2. As pressure systems, usually buried like municipal supply lines. In power developments, the trunk lines may be under terrific pressure; such penstocks are usually not buried.

3. As inverted siphons, or gas pipes, crossing depressions between sections of open canal. This type differs from the other two in being subject to an excess of air troubles and hydraulic-jump action.

Flow lines are usually of concrete or wood-stave pipe. The best practice at present is to bury a concrete or steel line, if subject to freezing, but to leave a stave pipe completely in the open so that it can be watched from day to day. Freezing appears to cause little difficulty in stave lines, even in very cold localities. Flow lines, or other lines under very low pressures, should not be constructed of untreated fir wood, as the life of such fir is highly dependent on the saturation of the wood. However, creosote-treated fir has long life both under pressure and in flow lines. Redwood is well known for long life under most conditions. Some organizations adopt a policy of using reinforced concrete for pressure lines where the head is moderate, and stave pipe or steel for the same lines under pressure heads in excess of, say, 60 ft.

For irrigation, pressure systems are widely used in fruit-growing areas, concrete pipe predominating in the citrus groves of California, Arizona, and Texas, and wood-stave pipe sharing honors with concrete in the Yakima and Wenatchee valleys of Washington. Naturally, sheet-metal pipe predominates in fruit areas where the system succeeded old mining canals, such as in the Placerville section of California. The sheet metal pipe was largely developed for hydraulic mining. Some metal pipe and some clay pipe also find their way into the other areas mentioned. Such irrigation pressure systems usually operate under low heads, and great strength is not required. Hand-tamped cement pipe has been wholly superseded by machine-made, centrifugally cast concrete pipe, although much of the cement pipe still in use is just as it was laid between 1880 and 1885. Wood-stave pipe, in sizes under 24 in., is nearly always of the jointed type; it is now made much better than formerly and there is less rotting of collars and corrosion of bands. In the larger sizes, from 24 or 30 in. to 16 ft in diameter, the stave pipe is made much as it was 40 years ago, although the materials have changed somewhat. Redwood pipe is made of "No. 1 clear stock" from the lower, heavier part of the tree. Nearly all fir used in stave pipe is now creosote-treated. This process lengthens its life; recent tests indicate that it also increases the capacity, apparently by making the wood less absorbent and hence less spongy after a long period of use. The spongy inner surface of an old untreated pipe is soaked with water which has no velocity and which, by virtue of its affinity for the water flowing past, retards the velocity over the entire cross section.

Trunk Lines of Full-Welded Steel Pipes Serving the City of Everett, Wash.

Until recently, nearly all metal pipe used for pressure systems in irrigation practice was of the light, slip-joint type, with all sheet seams held by flat-head rivets well masked in the asphaltum coatings. A later development was the use of the corrugated metal pipe so widely employed for road culverts. Corrugated metal has also been used to a small extent for irrigation pipes. However, in irrigation, smooth spiral-welded and other types of smooth-interior pipe have largely supplanted the older forms.

In hydro-electric development, concrete pipe has been little used. Wood-stave pipe is extensively employed for flow lines and for power drops under moderate heads, say, up to 300 ft or more. For high-head projects requiring heavy steel plate, various types of full or partially riveted pipes, and also pipes of smooth interior have been developed. In recent years pipe manufacturers have been directing their efforts toward the development of pipes having the lowest possible friction factors. Since rivet heads projecting into the water have great retarding effect, these heads are now countersunk in many pipes.

Heavy steel pipe is now masked in several ways so that it is hard to identify in the field. Many recently constructed lines have been covered with concrete coatings. Some have concrete both inside and out, the steel cylinder being used merely as a watertight shell. In such pipes, reliance is placed on steel-rod reinforcing cages, set outside the steel cylinder, to take the bursting stresses. Both sheet-steel and cast-iron pipe are now made with cement linings to increase capacity and reduce corrosion.

A pipe new to this country, although it has been used in Italy for 20 years or more, is made of neat cement and asbestos, in sizes from 2 or 3 in. up to about 30 in. This pipe has nearly the strength of cast iron, can be tapped for a corporation cock—like a cast-iron, steel, or wood-stave pipe—has a smooth interior, and is said to be free from electrolysis troubles.

In the sanitary engineering field, combinations of concrete and vitrified plates are extensively used where sewage old enough to be active in disintegrating ordinary concrete work is to be conveyed. The plates are set into concrete conduits of circular and other shapes.

Variations in Runoff of California Streams

Shifting Lake Levels Give Quantitative Indications Extending Back Three Centuries

By S. T. HARDING

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IN the February issue of "Civil Engineering," Professor Harding discussed the history of lake levels in the Great Basin and concluded that the dryness of the period since 1917 had been exceeded prior to that time. He here continues his analysis and makes a rough quantitative estimate of runoff in California as far back as 1650. There are sufficient records, he says, to indicate that the last 75 years have had a generally better runoff than any similar period during the last 200 to 300 years. Four general methods of developing the water supply of streams subject to wide variations in runoff are described. The current article is an abstract of a paper presented on July 4, 1935, before the Irrigation Division at the Society's Convention in Los Angeles.

RAINFALL and runoff in California have been less during recent years than in the period from about 1900 to 1917. As direct stream records in this area began about 1895, it has become necessary to revise downward many estimates of water supply made before the records of the past few years became available. The length and extent of the recent period of deficiency in runoff, with its resulting shortages in many areas, makes this an opportune time to review the available records and attempt to interpret them in relation to future development. It is particularly important that this be done for western areas, as the water supply is the limiting factor in their development. The relative variation in water supply both for single years and for series of consecutive years is greater in arid areas than where the rainfall is greater. This results in added difficulties in securing full use of the available runoff in years of average or above average supply without creating a development that cannot be maintained during periods of shortage.

In my efforts to determine the extent of past water-supply fluctuations in California, two types of records have been used. One consists of the direct measurements now available for about 40 years on enough California streams to furnish a general picture for this period; the other consists of evidence based on the fluctuations of enclosed lakes whose evaporation balances the inflow. Sufficient records are available for some lakes of this type to permit an estimate of their general range of fluctuation for the past 150 to 300 years.

Past fluctuations of lakes in the Great Basin area, determined from the evidence of trees, from early historic records, and from later direct observations, were discussed in my article in the February 1935 issue of CIVIL ENGINEERING. It showed that the evidence was generally consistent in indicating that these lakes were continuously lower for 150 to 200 years prior to 1860 than they have been since, and also that during the period prior to 1860 they were at lower stages than they have reached as yet during the present period of decreased rainfall.

That article was limited to fluctuations in lake elevations and did not attempt to estimate quantitatively the amount of the inflow. For such enclosed lakes, over long periods, inflow is balanced by evaporation. Whenever the inflow is greater or less than the evaporation, the lake rises or falls until the evaporation from the changed area again balances the inflow. The mean inflow for any period can be computed from the area and capacity curves of the lake, the rate of gross evaporation, the direct rainfall on the lake area, and the change in lake elevation during the period. The records necessary to compute inflow are available for three California lakes in the western Great Basin area—Tahoe, Eagle, and Mono.

THE EVIDENCE OF THE LAKES

Lake Tahoe, with an area of about 120,000 acres, is controlled within a range of 6 ft above its rim; within this range there is little variation in its area. Direct records of outflow from the lake, and lake stages, are available since 1900, and indirect records (deduced from dead trees in the lake area) have been carried back to 1700. Gross evaporation from the lake is estimated to be 3.07 ft in depth, or 370,000 acre-ft per year. The basis of estimate is records of the U. S. Weather Bureau obtained with a floating pan over a period of 14 years. The rainfall on the lake since 1900 was estimated from adjacent records, using a mean value of 24 in. per year. The rainfall for the period when the lake remained below the rim was estimated by comparison with that in similar recent years in which evaporation exceeded inflow.

Stumps of trees which grew below the elevation of the outlet indicate that the lake has been below the outlet elevation continuously for a period of over 100 years at some time in the past. During such a period inflow and rainfall on the lake are less than the evaporation. This period has been assumed, after study of other records, to have been prior to about 1850. While no direct records of the stage of Lake Tahoe are available prior to 1900, loggers would have left records of the lake having been below its rim if this had occurred for any long period after 1860.

The results of applying these records as a basis for estimating the inflow to Lake Tahoe are shown in Fig. 1. The records have been grouped in periods consisting of several consecutive years of similar inflow. The 11 years from 1901 to 1911 had an average inflow over twice as large as that for the last 11 years. The tree records indicate a long period when inflow was less than 60 per cent of the mean for the last 34 years of direct observation.

Eagle Lake, near Susanville, Calif., has an area at its higher stages of about 30,000 acres. The first direct record of its stage is that obtained from the location of the meander corners in the 1875 U. S. land survey; there are sufficient later records to determine its general fluctuations from that time to 1923. In the latter year the lake was tapped by a tunnel; records of the diversion have not been maintained and the inflow since 1923 can only be approximated from general climatic records. The mean annual rainfall on the lake is about 20 in. Precipitation records are available since 1870 from which variations in rainfall during different periods can be estimated.

The tree records indicate that from 1760 to 1850 the

lake was continuously below the stage to which it rose in about 1850. They do not show how much below the 1850 stage it may have gone; however, it did not stay sufficiently below this stage long enough for trees to grow at the lower elevations—or at all events, if trees did grow they did not attain an age sufficient to result in stumps which are still preserved. The oldest trees grew at elevations which have been used to give the lake stage from 1650 to 1725. Following 1725 the lake would have had to become lower to enable the lower trees to grow beginning in 1760.

The resulting computations of inflow are shown in Fig. 1. A mean inflow is indicated for the 200 years prior to 1850 of about 75 per cent of that from 1850 to 1923. Within the latter period, 26 consecutive years exceeded the mean inflow by an average of 20 per cent; the last 18 have had an average inflow of only about one-half the 73-year mean. Apparently other past periods of greater length have been as deficient in inflow as the last 18 years.

Direct records on Mono Lake date back to the first U. S. Land Survey in 1857. The rainfall on the lake decreases from west to east; a mean value of 10 in. has been used. Gross evaporation has been estimated as 3.2 ft per year. The estimates of inflow for different periods are plotted in Fig. 1. The indicated mean inflow for the last 77 years is materially larger than that necessary to maintain the lake at its 1857 level. Average inflow prior to 1857 had only been sufficient to result in the stage reached in 1857, even though there may have been fluctuations both above and below this stage. The shortage of the last 11 years is very marked. Mono Lake appears to have had a fairly continuous increased inflow from 1857 to 1919 as compared with that prior to 1857 and since 1919. The shortage of recent years has not reduced the lake to nearly so low a stage as that of 1857, and the recent rate of inflow would have to continue for many years before that stage would be reached again.

While Southern California is not subject to the same climatic influences as the Great Basin, some of its lakes furnish indications of a similar fluctuation in runoff. Lake Elsinore receives the surplus runoff of the San Jacinto River. It was practically dry in 1810 and 1859. It has also overflowed at times, the last spill occurring in 1916. Lake Elsinore would be expected to become dry more frequently now than in earlier periods because of the diversion for irrigation of much of its tributary inflow. It is stated by J. J. Prendergast of the Bear Valley Water Company that Baldwin Lake above Big

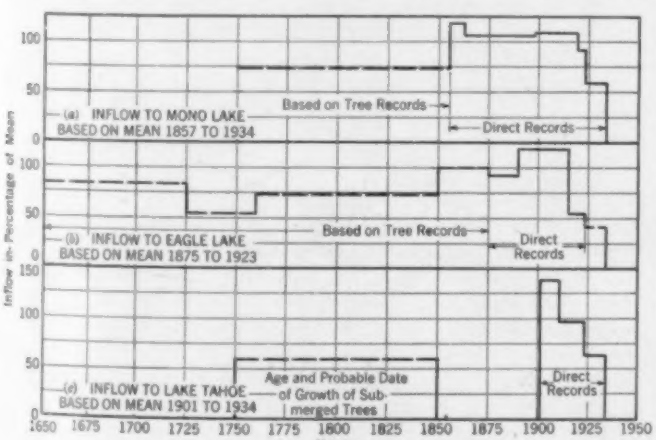

Fig. 1. Inflow to Lakes in Western Great Basin Area
As Deduced from Direct Records of Stage and the Evidence of Submerged Trees

Bear Lake rose high enough in 1916 to kill trees of considerable age; and that the Mojave River reached dry lake beds in that year which it had not filled within the knowledge of settlers in this area.

These records indicate a period of generally higher runoff in this area, reaching its peak in 1916, like that of the Great Basin lakes. This period in Southern California continued above the mean until the water year 1921–22,

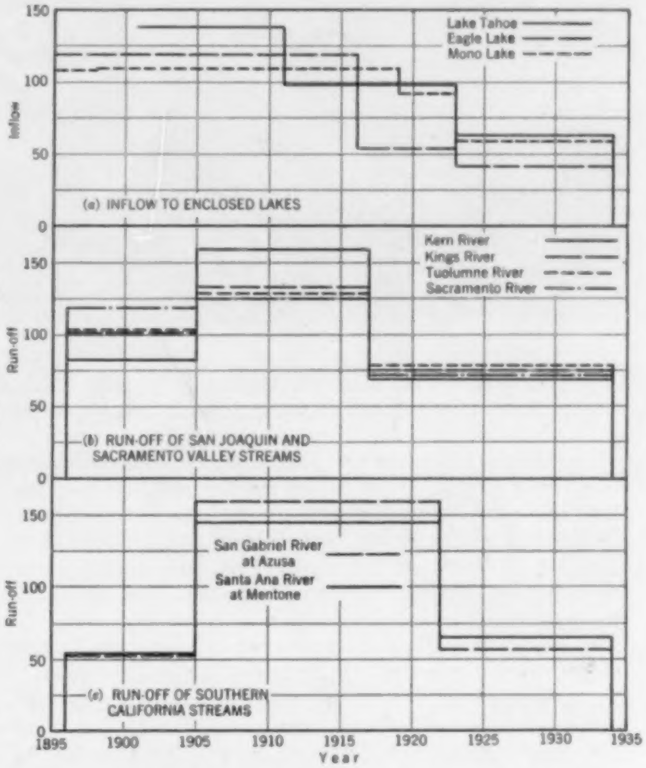

Fig. 2. Runoff of Streams in California and Inflow to Lakes in Western Great Basin, 1896–1934

in which year Lake Elsinore rose nearly as high as in 1916. However, Southern California experienced a period of deficient runoff ending in 1904, which is not shown by lakes in the western Great Basin (but which agrees with the fluctuations of Great Salt Lake).

THIRTY-NINE YEARS OF STREAM RECORDS

There are six important California streams, well distributed over the state, for which continuous records for the last 39 years are available. The Santa Ana River at Mentone represents a major part of the upper drainage area of this stream; the San Gabriel at Azusa includes practically all of its productive area. These two streams are typical of conditions in Southern California. The Kern River near Bakersfield includes the entire flow of this stream. Its drainage area is at the southern end of the Sierra and is subject to the overlapping climatic effects of southern and central California. The Kings River at Piedra and the Tuolumne at La Grange represent the entire runoff of these important streams draining the western slope of the Sierra above the San Joaquin Valley. The Sacramento at Red Bluff drains much of northeastern California and is representative of that part of the state.

Runoff for each stream has been expressed as a percentage of its 39-year mean. The results are shown in Fig. 2. To avoid variations of single years and to bring out more clearly the major sequences of large and small runoff, the 39 years have been divided into three periods.

These demonstrate the tendency of these streams to pass through periods of ten or more consecutive years during which the average runoff may depart widely from the mean. While some general similarity is shown in the occurrence of periods of excess and deficiency on the several streams, variations in runoff are evidently not uniform throughout California.

PYRAMID LAKE, CALIF., IN 1934

Fremont Sketched This Scene So Accurately in 1844 That the Water Line of That Date Was Easily Located from the Sketch

Variations from mean discharge, for shorter periods than those in Fig. 2, are shown on Table I. These variations are more pronounced for Southern California than for the rest of the state. Maximum 5-year periods may have 4 to 6 times as much runoff as minimum periods of the same length in Southern California, and only 2 to 3 times as much in the remainder of the state.

In Fig. 2 is indicated an extent of variation in runoff for California streams which is similar to that found for the enclosed lakes in the western Great Basin, although such variation may not be synchronous in time. Similar variations are shown for Southern California by Lake Elsinore. Consequently it is considered that the stream records for all California since 1895 include periods of runoff as large as, or larger than, any that have occurred within the last 250 years, and that the deficient periods are probably not as severe as some that have occurred in the past.

TABLE I. VARIATIONS IN RUNOFF OF CALIFORNIA STREAMS FOR PERIODS OF ONE TO FIVE YEARS

Item	Runoff in Percentage of Mean for the 39-Year Period 1895–1934					
	San Gabriel River near Azusa	Santa Ana River near Mentone	Kern River near Bakersfield	Kings River near Piedra	Tuolumne River near La-Grange	Sacramento River near Red Bluff
Individual Years:						
Minimum.......	9	23	27	24	29	36
Maximum.......	375	404	372	234	208	195
2 Consecutive Years:						
Minimum.......	10	24	40	40	48	48
Maximum.......	266	302	250	200	202	162
3 Consecutive Years:						
Minimum.......	14	29	43	44	49	50
Maximum.......	226	246	190	162	166	154
5 Consecutive Years:						
Minimum.......	30	48	58	62	69	55
Maximum.......	187	192	177	139	143	149

The studies discussed herein are considered to support the following conclusions:

1. Climatic conditions in California result in relatively long continuous periods during which runoff from streams may be materially above or below the long-time mean.

2. Southern California streams are subject to more severe and longer continued variations in runoff than streams in the nothern part of the state. The climatic influences of Southern California extend into the southern part of the San Joaquin Valley. The streams draining the northern part of the east slope of the Sierra have characteristics generally similar to those on the adjacent west slope.

3. Streams in Southern California are subject to periods of ten or more consecutive years in which the average runoff may be only about one-half of the long-time mean. They are also subject to similar periods in which the runoff may exceed $1^1/_2$ times the mean.

4. Streams in central and northern California are subject to periods as long as 20 consecutive years in which the runoff may be 25 to 30 per cent above or below the long-time mean.

5. These variations may result in accumulated departures from the mean of as much as 7 to 10 times the mean annual runoff in Southern California streams, and 4 to 5 times the mean in the rest of the state.

DEVELOPMENT OF WIDELY FLUCTUATING STREAMS

Development of water supplies in California is necessarily subject to variations in runoff. Either the development must be limited to the demand that can be met during periods of deficiency, or means must be found for retaining the runoff in periods of excess for use in years of deficiency.

There are four general methods by which the water supplies of streams subject to wide variations in runoff may be developed. The first of these is complete regulation entirely in surface reservoirs. This is seldom practicable, however, on streams subject to such extreme variations as those of California. Storage sites of sufficient capacity at practical costs are seldom available. Even with sufficient constructed storage, evaporation during the long periods of carryover will consume a large part of the supply stored.

The second conservation method utilizes underground storage and is extensively used on several Southern California streams. Fortunately there are large masses of coarse alluvial fill, which enable the runoff over relatively long periods to be equalized for use. Such alluvial fills represent economical storage relatively free from evaporation loss.

Several California streams have been developed by the third method, in which present demand is met from direct flow, with limited storage, and much of the runoff is still unused. This practice meets present needs but does not represent the full practical use of the available supply.

The fourth method is practiced on some streams where full surface or underground storage is not available. The dependable part of the flow is used on permanent development and the irregular flow is applied, when available, to grain or pasture. When diversion systems can be built cheaply, this may be a profitable form of use. Examples of this practice are the irrigation of grass lands on the San Joaquin River and grain from the surplus water reaching Tulare Lake. Recent dry years have resulted in a large reduction in these areas.

The preceding records and discussion demonstrate that all the runoff of California streams cannot be used for irrigation without the development of excessive carryover storage or a material variation in the area irrigated during different periods. Unless inexpensive storage is available or there are large areas of grain or pasture, we can only anticipate incomplete use of the runoff during series of excessive years. It may be more economical to permit such escape of runoff rather than to incur the costs necessary for its use. Each stream is an individual problem in this regard.

Planning Trends in State and Nation

Comprehensive Planning Is Stimulated Along Lines of Greater Social Significance

PROGRESSIVE views of a state's obligations toward its citizens, coupled with the evident need for assistance which many experience today, have brought into new prominence questions as to which and what type projects in the various communities constitute the best objects for the expenditure of public funds. An advanced conception of the responsibilities of the State of California to improve as far as possible the health, safety, comfort, and security of its residents is presented by Mr. Tilton as the first article in this symposium. The second article, by Mr. Fox, delineates the various standards by which projects proposed under the federal emergency relief program should be evaluated, and shows how readily insufficient study may make possible the approval of individual plans worthy in themselves but incompatible with one another. These subjects are timely and of great social significance. Both articles are abstracted from papers delivered on July 4, 1935, before the Planning Division at the Los Angeles Convention of the Society.

Objectives and Methods of State Planning

By L. Deming Tilton

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THE California State Planning Board has carried on all its activities in the belief that the need of planning is now recognized by all intelligent and responsible citizens. The members of the present Board, being the first to serve California in this manner, have a natural feeling of pride in the fact that they have had the privilege of inaugurating a work of such importance. They see it continuing, growing in strength, and rendering a service of incalculable value to the future state.

In all discussions of the state planning program, the importance of continued effort has been recognized. Planning in California is being developed as a necessary and permanent function of state government The Board has sought to avoid any show of enthusiasm or any performance which might lead to false assumptions regarding its purposes and character. It intends to proceed slowly and at every stage to be able to justify its existence.

The Board has devoted considerable time to discussions of the objectives and methods of state planning. It has attempted to state fundamental principles to determine a proper field of action, to consider basic policies and methods, and to develop a scale of values which can be applied advantageously to the vast array of challenging problems. These matters have seemed to be of greater significance than the plan itself throughout the present formative period.

Aerial View, Port of Los Angeles and Vicinity
The City of Los Angeles Appears in the Middle Background

CONSCIOUSNESS OF BASIC OBJECTIVES FUNDAMENTAL

A most important requirement for any responsible planning group is to learn why it exists and what it is expected to accomplish. An early understanding of this matter will improve the abilities of a state planning board and give its work wider acceptance.

The primary objectives of state planning in California

are: (1) to provide a greater measure of health, safety, comfort, and security for every citizen; (2) to open new avenues for the enrichment of life; (3) to conserve and develop with maximum efficiency all human and physical resources; (4) to provide social equipment which will reflect more adequately the natural wealth and advantages of the state.

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A LUMBER WHARF, LOS ANGELES INNER HARBOR
Lumber Tonnage Through the Port Is Decreasing

The attainment of these objectives is made possible through the establishment of responsible governmental control over the pattern of state growth and development. Up to the present, this development has been largely adventitious. In the 150 years since the first permanent white settlers came, many of the truly exceptional opportunities of the state have been lost. The fabulous quantites of easy gold are gone. Timber, soil, natural gas and oil, game, fish, and scenery are going, under conditions of exploitation and reckless disregard of social interests. The lack of planning has been costly indeed. But in the future, through foresight, conservative use and development of natural resources, and wise direction of all processes of growth and change, the pattern of California can be reorganized along more rational lines.

The ideals of the California State Planning Board are outlined in nebulous form in the simple code previously stated. In more specific terms these mean the encouragement of every movement which will spread the blessings of California more justly and more equitably among its people. The lowly Mexican, by whose labor the agricultural wealth of the state is produced, and the mechanic who asks only a sufficient income to live simply, are both entitled to a share of the California sun. Great numbers of humble people make up the population of this state. It is their state which is being managed by men who have had greater advantages and greater rewards, and it is they who suffer severely when it is mismanaged.

The laboratories have taught much regarding the effect of environment upon animals, but give little guidance to those who plan a fairer state. Thousands of small animals are kept in the Life Science Building of the University of California for experimental purposes. By manipulating temperature, air pressure, amount of sunlight, oxygen, and other gases in the atmosphere, and by changing the size, shape, color, and arrangement of cages, the scientists produce either strength or weakness, stupidity or intelligence, crulty or kindness, and almost any other qualities desired.

The homes, offices, factories, and other "cages" in which humans live and work are of their own designing. Because of this, it is possible to establish higher standards of environment, apply new principles of construction, and build structures and communities which will encourage the development of a stronger, wiser, more tolerant and, generally, more highly civilized race of men. The social equipment and natural wealth available in this state are guarantees that unparalleled results can be attained if the task of planning for such ends is once undertaken.

Such thoughts and aspirations give spirit and purpose to the work of the State Planning Board, even though its routine duties follow prosaic paths much of the time.

The field which a state planning agency is to occupy needs to be delimited. It is not a movement to reorganize business and industry. It is not economic planning, as that term is commonly understood. And it is not a program for the introduction of a new system of government. These problems, as well as those of morals, politics, law, and similar fields, except as they impinge upon or tend to warp unduly the physical pattern of the state, will not come within the purview of a state planning agency.

The state plan concerns itself primarily, but not exclusively, with the physical equipment—the lands, buildings, highways, parks, and other tangible things which Californians use in the conduct of their daily affairs or need for the attainment of a more abundant life. The field of planning, when thus defined, is amply large for all the talents brought into this work. The trained, experienced, professional planner, feels humble indeed in the presence of such a vast horizon.

METHODS OF STATE PLANNING

The task of planning can be simplified, by following a definite program. It is clear that the actual making of a plan is but one phase of the difficult problem of reaching the objectives seriously set forth. The technical job of plan-making can be assigned to a specially qualified staff with adequate facilities, but the preparation of a comprehensive planning program and the administration of such a program over a long period of years, require a great deal more than the production of pretty maps and pictures.

These visible evidences of planning effort are practically worthless if they serve merely as exhibit material.

INNER HARBOR OF LOS ANGELES
The Harbor Belt-Line Railroad Encircles the Port

The most difficult job which any planning agency has is that of giving its plans a proper degree of authority. Some of the handicaps and limitations which operate to make planning an exceedingly difficult governmental function may be mentioned briefly:

1. The planning board lacks authority; it can only recommend and advise. The corrective is development of power and influence through possession of facts, keen analysis, wise foresight, and application of consistent principles.

2. The functions of the planning board are not understood by the members themselves; as a consequence it lacks efficiency. Politics may mar judgments, for friends count more than facts, and sectional or personal interests color decisions. Meetings get out of control; anecdotes or speeches absorb valuable time and divert attention; and the work which only the board can do is left undone. A board of well-chosen citizens, intently following the process of planning, is an important counterbalance to the group of technical men.

3. Essential cooperation of officials may be lacking. The work of a planning agency may be regarded as unnecessary, ineffective, unimportant, or antagonistic by strongly entrenched departments. Natural human reactions, such as pride, jealousy, and ambition, frequently stand in the way of effective planning.

4. Confidence in the planning group may not have been developed. This may be due to the caliber of the board itself or the character of its membership. It may also be due to the inadequacy or incompetence of the technical staff. Lack of funds or facilities for making plans effective may also be responsible.

5. Planning methods may be faulty. This is largely the responsibility of the staff. The selection of suitable personnel for the direction and conduct of its work is most important.

The above summary indicates the dual responsibility of the planning group, which is a matter of even greater importance in state than in local planning. A state planning board which develops a proper sphere of influence and service in state government will have many of the characteristics of a court. The board may be called upon to adjust conflicts of interest arising out of the uses of property, and its decisions may affect the welfare of the state for generations. It may formulate policies, set standards, or state principles which profoundly change the pattern of state development. It may render strong adverse decisions against some of the promotional schemes, fantastic plans, or dangerous policies of misguided public officials. A planning board has a service to perform for the future state, which far exceeds popular understanding.

The present Congress has recognized this in the endorsement, by the Commerce Committee of the Senate, of the Copeland bill providing for a National Planning Board of five, each to be paid $12,000 annually. The scope and character of the work which such a board will undertake must justify Congress in giving it equal standing with the Interstate Commerce Commission, the Federal Trade Commission, and similar quasi-judicial agencies.

The working staff which the board selects, however, must have a large share in the responsibilities. It must assemble data bearing upon the future development of the state; analyze and interpret such data for the purpose of determining trends, causes, relationships, and probable future effects; develop plans expressing the basic principles adopted by the board; maintain contacts with other departments and governmental agencies as a means of securing essential coordination of effort; and prepare for the board, for officials, and for the public, the material required for a thorough knowledge of the processes, purposes, and value of planning.

The functions of the staff may be clearly distinguished from those of the board. The exercises of judgment and discrimination, the ability to state fundamental planning principles and to compel their recognition in various fields of government, are all duties and responsibilities which fall upon members of the planning board. The board is the custodian of the plan and its interpreter. The staff does the day-by-day work. The two, working together, seek practicable solutions of those problems of organic development which are certain to arise as the state develops and its character becomes more complex.

Where its sphere is properly defined, general comprehensive planning is kept distinct from the detailed planning which must precede actual construction. There is no need for the planning agency to attempt to occupy any field now capably filled by an existing state agency. The planning board cannot, without undue arrogance and a degree of presumption which will destroy its usefulness, expect to substitute its judgment for that of older, more experienced, and more responsible state departments. The state planning board should assemble and interpret facts for the information and guidance of other governmental agencies, and should overlap the fields of these other agencies only so far as may be necessary to create, throughout the entire state, a coordinated, balanced, and harmoniously developed physical plant for the service of the people.

Planning Emergency Public Works

By William J. Fox

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The Fourth Deficiency Act, which was passed by Congress on June 16, 1933, provided for the appropriation of $3,300,000,000 for work-relief projects. A second act, known as the "Emergency Relief Appropriation Act of 1935," providing for an appropriation of $4,800,000,000 for similar purposes, was passed by the present Congress on April 5, 1935. Both acts provide for financial participation by the federal government with local governments, and as such they represent an innovation in public works financing. Naturally problems were encountered in dealing with public works under this new method of financing, as it involved novel legal questions and a more thorough study of engineering details and in particular necessitated a study of population trends, and of such needs of modern society as low-cost housing, zoning, decentralization versus centralization, and taxation.

The principles of city and regional planning have been

actively brought into the field because of the necessity of determining whether or not and to what extent the federal government should participate in the financing of local public works projects. The federal government is interested only because, and to the extent that, public works better the social condition of our citizens, tend to lower the cost of government by better and more efficient living conditions, and provide a pattern of community development which represents a guide for the efficient expenditure of all public funds. No public works project can be dealt with without ascertaining what part it plays in the comprehensive plan for the development of the community.

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EAST CHANNEL, LOS ANGELES HARBOR, SHOWING U. S. NAVY LANDING AND COTTON COMPRESSES

NECESSARY CRITERIA FOR PUBLIC WORKS PROJECTS

The time element involved in the formulation of the construction and relief program under the act of 1933 did not permit of the preparation of comprehensive plans for spending this money on a well-rounded, well-balanced, planned program. Taking into consideration the fact that the aims and purposes of the act were to relieve unemployment, such a program should have the following characteristics:

1. The money should be spent in locations and on projects affording the greatest and most expeditious relief to unemployment;
2. The money should be spent on needed and permanent projects;
3. The projects should be so selected as to form a material contribution to the social and economic welfare of the people of the country, with as little injury as possible to private business;
4. The projects should be so interrelated as not to be antagonistic to one another;
5. The projects should be capable of being economically maintained after construction;
6. The projects should be part of a six-year budget plan of construction, and of a long-range program of public works for the community.

The following typical example illustrates the failure to observe certain of these principles in the applications for funds presented to the federal government for approval. One political subdivision submitted several hundred applications for federal funds, which were prepared by the several departments having direct jurisdiction over the respective projects. These included projects for road construction, flood control, bridges, sewers, storm drains, and buildings. It was then discovered that many of the roads as well as many of the other works contemplated under these projects, would have been completed inundated by water impounded by the flood control projects, if the applicant's projects had all been approved as submitted. This condition occurred again and again in connection with projects submitted by cities, counties, and states, because there was no coordinated central planning which involved all the public works. The problem was further complicated by the fact that projects submitted by adjoining cities, or by adjoining cities and counties, would be in many instances in conflict with one another, unrelated, and uncorrelated. If the federal authorities had approved all these projects, the economic loss and waste would have been terrific.

The needs of civilized society have become so great, our communities have grown so large, the ramifications of public service are so numerous, and the departments of government have multiplied to such an extent that their correlation through the process of comprehensive planning is today an absolute necessity—one which calls for the exercise of the best professional talent from the standpoint of engineering, economics, law, finance, architecture, and art.

FEDERAL GOVERNMENT RECOGNIZES NECESSITY FOR LARGE-SCALE PLANNING

In recognition of these conditions, the federal government was prompted to follow the recommendations of its various departments by forming the National Planning Board, later designated as the National Resources Board. This latter board has now become a permanent governmental entity, identified as the National Planning Committee, and made up of the following: Harold L. Ickes, Secretary of the Interior, chairman; Frederic A. Delano, vice-chairman; Daniel C. Roper, Secretary of Commerce; George H. Dern, Secretary of War; Henry A. Wallace, Secretary of Agriculture; Frances Perkins, Secretary of Labor; Harry L. Hopkins, Federal Emergency Relief Administrator; Charles E. Merriam; and Wesley C. Mitchell.

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MAIN CHANNEL AND INNER HARBOR, LOS ANGELES
The Main Channel Is 1,000 Ft Wide and 37 Ft Deep

Through the efforts of the National Resources Board

and the Public Works Administration, the states have in turn formed state planning boards. These agencies have closed the gap in the planning picture, and tie in, in a national way, the work and functions of the city and county planning commissions which have been established throughout the country. For the first time in its history, this nation has set up a structure whose purposes and objectives are the comprehensive planning of the physical development of the community, state, and nation in a related and well-balanced sense.

Many engineers have conceived, designed, and constructed projects only to find that, upon completion, the subjects of the work were placed in jeopardy by some seemingly unforeseen circumstance or trend of events which greatly detracted from the efficiency of the project.

A city engineer may have built a sewer system in a district assumed to be strictly residential, only to witness in a short time its conversion to apartment-house use. The resulting increase in density of population might soon render the sewer system inadequate, and entail great financial loss on the owners of other under-sized facilities, such as transmission lines and treatment plants. Correcting this condition may well cause further losses by the tearing up of streets and consequent traffic delay. Similar unplanned developments have caused corresponding losses in water systems, telephone systems, and utilities generally. After bridges have been built it has often been found that an unanticipated shifting of traffic flows has rendered them obsolete the day they were completed. These are some examples of what has been occurring over a period of years and thus are of universal application.

The development of our communities has not been guided by advanced planning. Population trends have not been controlled by zoning. True, we have used these facilities to some extent, but not to the degree required for a solution of the problem. While the expenditure of the first appropriation of $4,300,000,000 permitted of but little comprehensive planning, it did cause a start to be made. It caused the authorities to be conscious of the need. It caused those most skeptical of this newer science to pause and take due note that there was something lacking, something preventing the fulfillment of an intelligent, expeditious, and efficient spending of an unprecedented sum dumped overnight into the laps of government officials.

It is not to be expected that this newly developed planning structure will immediately produce startling results. First, it must have the services of men experienced in that field of endeavor. Second, it must have the sympathetic understanding of those interested in specific projects. Third, it must be diligent in its purpose and free from political intrigue.

The government is cautiously pioneering in this new field, and gradually applying the principles of comprehensive planning. One of its first ventures was power development in the Tennessee Valley, under the direction of the Tennessee Valley Authority. Another that is gradually being developed is the project dealing with flood control, water conservation, power development, housing, and transportation in the Mississippi Valley. All of these touch every citizen, and at the same time lay a foundation and a framework for stabilizing the economic structure of both large and small communities.

REPORT OF THE NATIONAL PLANNING BOARD

The need for plans and planning in connection with public works can best be described by quoting from the foreword of the report made by the National Resources Board to the President on December 1, 1934. This was the result of a close scrutiny of the reports of the departments of the federal government dealing with natural resources, together with a survey by the Department of the Interior and the Public Works Administration of all applications submitted to it for federal loans and grants. Page 5 of the report states:

"This report . . . brings together, for the first time in our history, exhaustive studies by highly competent

West Basin, Los Angeles Harbor
View Taken at Berths 145 and 146

inquirers of land use, water use, minerals, and related public works in their relation to each other and to national planning . . . . An examination of the reports upon land, water, minerals, and public works, respectively, shows the importance of considering these special factors in their relations to one another, and to economic and governmental problems as well. Water policies and land policies cannot be planned except as taken together. . . . Erosion is a problem of land and water; afforestation is likewise a problem of land and water; flood control is related to navigation and also to land cultivation systems. Water pollution is closely related to industrial development, as well as to sanitation, urban, and rural. Reclamation policies are inseparable from the agricultural policy of the nation, while the recreation policies discussed in relation to land and water are appropriate to any comprehensive plan for social welfare."

In the light of this report, it is easy to understand why it is impossible to deal intelligently with a single application in a public works program without the aid of basic plans which reveal the predetermined character of the community that the particular public work is designed to serve. Furthermore, there should be equally well-prepared plans showing periodic trends and stages of development toward the objective set forth on the basic plan. There should also be general plans to show existing conditions that should be corrected progressively over a period of time in order that the fulfillment of the community's objective may be realized. The plans would then provide a basis for determining whether or not a particular project is timely, its appropriate location, whether its size and magnitude are consistent with the need and expenditure, and what future additions or expansion would be necessary. In general, with comprehensive planning, expenditures of public funds will be more in keeping with known factors and will eliminate the wild guesses that only lead us further into the depths of chaos and confusion.

Combating a Saline Invasion in California

Plans Are Prepared for Protection of Sacramento–San Joaquin Delta Region

By Edward Hyatt

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In the dry period since 1917, salt water has been invading the channels of the Sacramento–San Joaquin delta to an unprecedented extent, causing crop losses, damaging industrial equipment, and curtailing municipal, industrial, and irrigation water supplies. Various agencies, including the War Department, the Bureau of Reclamation, and the State of California, have made extensive studies of two possible remedies, one based on regulation of river discharge and the other involving construction of a barrier in the bay. The accompanying brief discussion of the situation and its proposed remedies is abstracted from a paper presented by Mr. Hyatt on July 4, 1935, before the Waterways Division of the Society at the Annual Convention in Los Angeles.

In the fall of 1919, a dock supported by untreated timber piling on the shores of upper San Francisco Bay suddenly collapsed, precipitating several loaded freight cars into the bay. This was the first of a series of similar failures in the upper bay, which continued during the next two years, causing an estimated damage of $25,000,000 up to 1921. The agent of destruction was the teredo navalis.

This situation was one of many which marked the advent of abnormal salinity in the channels of the upper bay and the delta of the Sacramento and San Joaquin rivers (Fig. 1). In the succeeding years, large losses were incurred by industrial, commercial, agricultural, and municipal interests. Numerous industries located along the shores of the upper bay experienced serious difficulties, corrosion destroying pipe lines and other equipment. Several of the towns bordering the upper bay and lower river found their municipal water supplies seriously curtailed, beginning about 1917, because of a greater degree and duration of saline invasion, and water had to be hauled in in tank cars until new supplies could be developed. In 1920, salt water advanced into the delta to such an extent that at the time of farthest advance 20 per cent of the lands in the Sacramento–San Joaquin delta had water in the adjacent channels too saline for irrigation use, and there were substantial losses in crop production.

Believing that the abnormal invasion of salt water was due to increased upstream diversions from the Sacramento River, in 1920 the land owners in the delta combined with the City of Antioch in instituting a lawsuit against upstream appropriators, seeking to enjoin further diversions. This suit resulted favorably for the defense, but brought to public attention the seriousness of the salinity problem and focused attention on the necessity of remedial measures.

Four years prior to this suit, investigations of salinity had been started under the auspices of the State Water Commission. In 1929 and continuing through 1930 and 1931, these investigations were considerably enlarged by the addition of new salinity observation stations, measurements of tidal currents and fluctuations and of consumptive use of water in the delta and upper bay channels, and special surveys to determine the relation of salinity variations to stream flow and tidal action. In the meantime, other investigations were initiated. These considered particularly the possibility of constructing a physical barrier at some point below the confluence of the Sacramento and San Joaquin rivers to artificially control the invasion of salt water.

THE PROBLEM OF SALINITY

The invasion of saline water into the upper bay as far as the lower end of the Sacramento–San Joaquin delta is a natural phenomenon which has occurred annually, as far back as there are historical records. Under conditions of natural stream flow, however, before upstream irrigation and storage developments occurred, the extent of invasion and the degree of salinity reached were considerably less than during the period since 1917.

Beginning in that year, an almost unbroken succession of subnormal years of precipitation and stream flow has combined with increased upstream diversions from the Sacramento and San Joaquin river systems to produce a degree, extent, and period of saline invasion greater than any previously known. Some of the earlier results have already been described.

The developments chiefly affected are the Sacramento–San Joaquin delta and the adjacent delta uplands, chiefly devoted to agriculture; the marshlands adjacent to Suisun Bay; and the industries, municipalities, and upland agricultural areas adjacent to Suisun Bay.

Fig. 1. Sacramento–San Joaquin Delta and San Francisco Bay Regions Showing Limits of Saline Invasion, and Typical Salt-Water Barrier Sites

The delta proper, with a gross area of nearly half a million acres, contains some of the richest agricultural land in the state, of which about 350,000 acres are actually cultivated and yielding crops of a normal annual value of some $30,000,000. The land lies at about mean sea level, and has been fully reclaimed with levees and drainage systems. Irrigation is essential, and water is obtained from the delta channels. Total consumptive use varies from a minimum of 400 cu ft per sec in midwinter to a maximum of 3,700 cu ft per sec in mid-August, with an average consumption during July and August of 3,500 cu ft per sec. During the summer months of several years since 1920, stream flow into the delta from the Sacramento and San Joaquin rivers has been insufficient to supply the consumptive demand. Invasions of salt water into the delta channels, particularly in 1920, 1924, 1926, 1931, and 1934, rendered the water unfit for irrigation over a considerable area of the delta in the latter part of the irrigation season, affecting a maximum of 70 per cent of the irrigated acreage in 1931. Water with a salinity in excess of 100 parts of chlorine per 100,000 parts of water is considered unfit for irrigation.

The marshlands adjacent to Suisun Bay have been affected less adversely, because fresh water had not been available continuously in former years as in the delta. However, the period of availability of fresh water in the Suisun Bay channels has been reduced, thus curtailing irrigation on an area of about 5,000 acres and increasing the difficulties of removing salt from the marsh soils. About 46,000 acres are within levees.

Industrial development along the shores of Suisun Bay is of considerable magnitude, representing (as of 1929) a capital investment of about $43,000,000, an annual payroll of about $13,000,000, and a gross annual value of products of about $112,000,000. All factors are favorable with the one exception of fresh water supplies, which at present are obtained partly from the bay and lower river channels, partly from private wells, and partly from public water-supply systems.

The advance and retreat of salinity in the upper bay and delta channels are the result of the opposing forces of tidal flow and stream flow. The waters of San Francisco Bay are a combination of the salt water, which enters the bay through the Golden Gate, and the fresh water of the Sacramento and San Joaquin rivers and local streams of the San Francisco Bay basin. The salinity varies markedly both from place to place and from time to time, and depends on the amount of fresh water discharged by the streams. When the streams are in flood the upper bays and channels are often filled with fresh water, and it is stated that during extreme floods, fresh water has been found even as far down as the Golden Gate. When the flow of the streams is small during the summer and fall months, the water in the upper bays and tidal channels, up to the lower reaches of the Sacramento and San Joaquin rivers, generally becomes saline and remains so until the first floods of the succeeding winter season. The flow of the Sacramento and San Joaquin rivers is the major factor affecting salinity in the tidal channels. These two great river systems have a combined discharge ranging between 6,000,000 and 80,000,000 acre-ft per season, with an average of about 31,000,000 acre-ft. Eighty per cent or more of the total seasonal flow is generally discharged during the first six months of the year.

Saline waters generally start to enter the channels at the lower end of the delta in the latter part of June, and the period of invasion continues until November or December, when the first winter freshets of magnitude usually occur. During the remainder of the year the water in the entire delta is fresh. Salt water advances into Suisun Bay much earlier in the year and remains there longer. However, the bay becomes entirely fresh for a while in the winter and spring months of many years.

Studies have revealed that, at any particular point or section in the upper bay and delta channels, there is a rate of stream flow which will equalize tidal action and prevent the advance of salinity beyond that point, and that this rate of flow varies with the saline content already present in the water.

Agriculture Flourishes in Sacramento–San Joaquin Delta
The Crops Include Asparagus, Potatoes, Sugar Beets, Truck, Alfalfa, Wheat, Barley, Pears, and Peaches

METHODS OF CONTROLLING SALINITY

Two methods of control have been given careful consideration. These are control by stream flow, and control by a physical barrier at some point below the confluence of the Sacramento and San Joaquin rivers. The first method may be designated as a "natural" means of control. Its primary requirement is the furnishing of water from upstream storage, supplementing the natural flow sufficiently to prevent the advance of salinity in harmful degree beyond a particular location. The most practicable point of control was found to be in the vicinity of Antioch. A flow of 3,300 cu ft per sec in the combined channels of the Sacramento and San Joaquin rivers at Antioch would control salinity to a maximum of 100 parts of chlorine per 100,000 parts of water at that point. Ten miles or more upstream the maximum concentration would be reduced to 10 parts in 100,000.

This method of control would positively ensure the adequate protection of the delta from saline invasion. This statement does not rest upon theory alone, but is supported by the observed occurrence of "natural" control effected by stream flow during the period of investigation. Moreover, with fresh water maintained in the delta channels, a nearby, dependable supply of fresh water would be made available for the industrial, municipal, and agricultural developments of the adjacent upper San Francisco Bay area. The gross inflow required to furnish the control and supply the consumptive demands in the delta would vary from a minimum of about 3,700 cu ft per sec in midwinter to a maximum of 7,000 cu ft per sec in midsummer.

The conception of a physical barrier to prevent invasion of salt water into tidal channels is not new. Such a barrier was suggested for the San Francisco Bay area shortly after the problem began to be acute, and the

proposed structure became generally known as "The Salt Water Barrier."

In the studies of its possible location and design, the following objectives and limitations were considered to be governing: (1) structure to be below the confluence of the Sacramento and San Joaquin rivers, and as far downstream as practicable in order to obtain maximum benefits; (2) minimum interference to be made with existing interests; (3) structure to be of sufficient height to dam off the lower bay waters at highest tide during storms; (4) suitable navigation locks to be provided, (5) flood openings with suitable control to be provided, with capacity sufficient to pass the largest floods without appreciably raising the flood plane adjacent to the reclaimed lands in the upper bay and delta areas; and (6) provision to be made for the passage of migratory fish.

Detailed designs were made for an upper, an intermediate, and a lower location. In general, they provided for locks and flood gates of massive concrete on one side of the channel, with the rest of the structure designed as a rock-fill dam made tight by filling the voids with mud. The crest elevation was about 10 to 15 ft above mean sea level. Navigation locks were of standard design, with a "salt clearing" lock to prevent entrance of salt water during lockages considered as an alternate. Flood gates were of the Stoney type.

CAPITAL AND ANNUAL COSTS

Capital and annual costs of a salt water barrier in the three locations considered were estimated as follows:

Site	Costs	
	Capital	Annual
Upper (Chipps Island)	$40,000,000	$3,300,000
Intermediate (Dillon Point)	50,000,000	3,900,000
Lower (Point San Pablo)	75,000,000	5,600,000

Salt-clearing locks would require an additional capital cost of from $3,500,000 to $7,000,000, and an added annual cost of from $300,000 to $700,000.

Contrary to a somewhat prevalent idea, a physical barrier would not, in itself, positively prevent invasion of salt water above the structure. Such an effect would be possible only if it could be built and operated as a continuous tight dam. Obviously, unless the salt water entering a barrier lake were flushed out, it would tend to accumulate and destroy the usefulness of the lake as a fresh-water supply. Hence, supplemental water would have to be furnished to control salinity, even with a physical barrier.

Studies, augmented by experiments by M. P. O'Brien, Assoc. M. Am. Soc. C.E., were made to determine the effect of the entrance of salt water through standard locks, and the amount of water that would be required to flush out the salt water to prevent its accumulation. It was found that comparatively large quantities would be required for this purpose. In addition, water would be required to take care of direct leakage through the gates at low tide, to operate fish ladders, and to compensate for evaporation losses over the lake area. The minimum total amounts required for control during the critical summer period are estimated for present and future conditions at the three typical sites as follows:

Site	Rate of Flow in Cu Ft per Sec	
	Present Conditions	Future Conditions
Upper (Chipps Island)	900	1,200
Intermediate (Dillon Point)	1,900	1,500
Lower (Point San Pablo)	3,600	3,300

If these flows are compared with that required for control by stream flow (3,300 cu ft per sec), some idea will be obtained of the possible saving in water by control with a barrier. For future conditions, the average annual saving by barrier control in water required from upstream storage is estimated to range from 280,000 acre-ft at the upper site to 150,000 acre-ft at the lower, including credit for usable barrier-lake storage.

OBJECTIONS TO A SALT WATER BARRIER

A salt water barrier would not be without detriment or disadvantage. It would be a hindrance to navigation, a possible menace to the fishing industry, and a complicating factor in sewage disposal. Studies made by the U. S. Army Engineers indicate that a barrier at a lower site, such as at Point San Pablo, would so greatly reduce tidal flow through the Golden Gate that it would seriously affect the maintenance of the navigation channels across the bar outside the Gate, and would also have some detrimental effects on the channels in the bay proper below the site. A barrier at either an intermediate or upper location would have much less effect on tidal flow.

The interference and delay due to lockages would be greater the farther downstream a barrier were located, because of the greater volume of traffic. It is estimated by the Army Engineers that the average delay to vessels due to lockage would be one-half hour, and that the average monetary loss per vessel per lockage would be $4.50 under present conditions and $7.50 under future conditions. The estimated resultant total annual loss to navigation interests ranges from $100,000 at the upper site to $243,000 at the lower site for present traffic, and from two to three times these amounts for future traffic.

Studies made by the State Fish and Game Commission indicate that a salt water barrier might be seriously detrimental to the fishing industry. It would offer an obstruction to the free migration of fish and would substantially reduce the shallow brackish-water areas essential as a feeding ground for young fish fry and for adult striped bass and shad.

A barrier would also create a problem in the disposal of sewage and industrial waste. These wastes are now discharged into the bay and rivers and, under the movement of tidal currents, are effectively disposed of without creating a nuisance. However, the dumping of such wastes into a barrier lake would seriously curtail its use as a source of fresh water supply. The extensive supplemental works required to intercept and convey sewage and industrial wastes to some point below a barrier structure, would entail additional costs of several million dollars.

In regard to the effects on river regimen, it may be stated that a barrier would have little tendency to cause silt deposits or raise flood crests.

ADOPTED PLAN FOR CONTROL OF SALINITY

Space does not permit discussion of the economic studies made of the relative costs and merits of the "natural" and "barrier" methods for control of salinity. The costs of the two schemes, combined with those of facilities for furnishing adequate water supplies for both present and ultimate needs in the upper bay and delta regions, were determined on a strictly comparable basis, allowance being made for the value of benefits or detriments not common to both plans. It was found that a plan of water service for the entire area, with salinity control by stream flow, would have capital and annual costs less than half those required for a plan of equivalent scope and service with a salt-water barrier. The adopted plan for control of salinity by stream flow is an important feature of the Central Valley Project of California.

Recent Advances in Steam-Plant Design

A Discussion of the More Important Developments of the Past Fifteen Years

By Thomas T. Eyre

Professor of Mechanical Engineering, University of Southern California, Los Angeles, Calif.

In few fields of engineering activity has progress during the past 15 years been so rapid as in steam-plant design. Many plants new in 1920 were obsolete a decade later. There is now in operation a steam-turbine unit with a capacity of more than 200,000 kw—30 years ago the largest engine was about one-fiftieth that size. The 300-lb pressures of 1920 have been superseded by pressures four and five times as great. Highly efficient methods of burning fuels have been developed. Three plants using both mercury turbines and steam turbines—a combination having certain definite advantages—are already in operation in this country. These and many other recent developments are discussed in an interesting and not too technical manner by Professor Eyre in the accompanying article, abstracted from his paper presented on July 4, 1935, before the Power Division at the Los Angeles Convention of the Society.

During the past 15 years there has been a great increase in the thermal efficiency of steam plants. In the days before 1920 coal was by far the most common fuel used in steam plants; it was fired in lump form, and in order to approximate complete combustion a large excess of air was necessary. The products of combustion were not at a very high temperature compared to modern standards, and low-grade refractory furnace linings were satisfactory. Fire brick was the common material. When less excess air came to be used and furnace temperatures rose, the old lining materials failed to give satisfactory service. Better refractories were produced, but even these could not stand the intense heat, so air- and water-cooled walls were tried. The latter have proved particularly successful. Many modern plants use exposed tubes that keep the walls back of the tubes reasonably cool. Of late years the distance from the burners or grates to the boiler surfaces has been greatly increased to allow sufficient time for combustion. Consequently smoke is seldom seen coming from a modern stack.

Before 1920 pulverized coal had been successfully used by the manufacturers of portland cement. Power plant engineers experimented for several years before they were able to use it satisfactorily. Shortly after the War, however, the problems incident to its use were solved, and it became a common type of firing. The fineness of pulverized coal corresponds roughly to that of portland cement. In this finely divided state the fuel can be intimately mixed with air, and the burning resembles that of gas or atomized oil.

There are two general schemes of utilizing pulverized coal. In one, the coal is pulverized, and stored in bunkers, from which it is drawn to the various burners as needed. In the other, the "unit" system, the primary air for combustion passes through the pulverizer itself and there picks up the coal on its way to the burner. There is no storage of coal in the pulverized form.

It seemed for a while that pulverization would displace the mechanical stoker, but competition stirred the manufacturers of the latter to improve their product, and it has remained in successful competition.

For highest overall plant efficiency, all of the heat that is given to the engine must be given at the highest temperature reached in the cycle of operations. In modern plants, however, furnace temperatures are between 2,000 and 3,000 F, while steam temperatures higher than 800 F are seldom used. This means that in the engine we fall far short of utilizing the maximum temperature range available in the entire plant. On the other hand, overall furnace and boiler efficiencies in modern plants are very high. Ordinary operating efficiencies may be around 85 per cent and, under test conditions, are sometimes over 90 per cent. The efficiency of modern turbines, based on the energy it is possible to extract within the temperature range under which they operate, is nearly as high as that of the boiler and furnace. The big loss in efficiency is due to the sharp drop in temperature between the furnace and steam. Our boilers and turbines are made of metal, and no metal will hold its strength at furnace temperature. Mild steel undergoes a marked loss in strength, and exhibits the phenomenon of "growth" or "creep" at temperatures over 800 F. Hence, up to the present, we have been forced to keep our steam temperatures at about this limit. The addition of certain alloying elements, notably nickel and chromium, may inhibit creep, but serves to move upward only a little the safe temperature at which steam can be generated.

Prior to 1920 there were few, if any, plants in this country that carried over 300 lb of pressure. With the perfection of design and construction, it has become safe to raise steam pressures to much higher values. Numerous plants now operate at from 600 to 800 lb. There are many that carry from 1,200 to 1,400 lb, and a few, mostly foreign, even operate at 1,800 or above.

In the old days, when combustion rates were low, draft was secured by tall chimneys. As the demand for greater draft developed, the stacks were made taller and taller. When mechanical stokers were perfected, chimney draft became inadequate and fans were added. However, tall stacks are quite expensive, both in first cost and upkeep, and the designer now usually finds that the greatest economy is attained with but little recourse to chimney draft. Stacks are consequently not as high as they used to be.

ECONOMIZERS AND PREHEATERS

With high steam pressures, boiler temperatures are high. The stresses caused by the sudden injection of cold water into a hot boiler might be dangerous, hence it is almost universal practice with high-pressure boilers to preheat the feed-water. Before 1920 this was done by exhaust steam from auxiliary equipment, but now that the electric drive for auxiliaries has become common, the preheating is done with steam bled from the turbines. Rapid combustion and evaporation and high furnace temperatures cause high stack temperatures, which unless care were taken, would result in low overall plant efficiency. To salvage as much as possible of this loss, economizers came into fairly general use. The economizer uses some of the heat of the stack gases to raise

the temperature of the feed-water. As forced and induced draft became more common, the economizer came to be considered standard equipment.

Shortly after the War the first large air preheaters were tried. The air preheater takes heat from the products of combustion on their way to the stack and gives it to the air to be used for combustion. Its source of heat is the same as that of the economizer. Since both the air preheater and the economizer salvage the heat of stack gas, it might appear that they would be equally good, but in the rivalry between the economizer and air preheater the latter seems to be winning. Some of the newer plants have entirely eliminated the economizer. This is due largely to the fact that the best way to heat the feed-water is by steam bled from the turbine; this leaves the air preheater as the logical means of salvaging heat.

IMPULSE AND REACTION TURBINES

An earlier era witnessed the replacement of the reciprocating engine by the turbine. In 1920 there were in use two general types of turbine, one operating on the impulse principle, and the other on a combination of impulse and reaction. In the years since then the two types have maintained about the same relative importance. I think the statement may safely be made that, for high pressures, the impulse type has somewhat the advantage. There are many turbines in which the high-pressure stages are impulse, and the low, reaction.

Since 1920 the size of units has increased; the limit for either turbines or generators has apparently not been reached. Size seems to be controlled by the consideration of total load and load factor. The modern steam turbine does not operate very efficiently at light load or at large overload; therefore the total capacity is broken up into such a number of smaller units as economic considerations justify. It may be that as the intensity of power demand increases, there will be larger units than now exist. The largest unit at present is at the state line plant south of Chicago. This is rated at 208,000 kw. It is interesting to remember that in 1905 the largest engine was 5,000 hp.

Since the efficiency of a heat engine depends on the temperature range existing in the cycle, and since the temperature of saturated steam depends on its pressure, for high efficiency we must have a high pressure difference between the entering and exhausting steam. The upward trend in pressures has been remarkably rapid in the past few years. On the other hand, the lowest possible exhaust pressure seems to have been reached. After the turbine came into general use, condenser design went through a period of rather rapid change until at present the condenser temperature approaches within a very few degrees the temperature of the available circulating water. It is hard to imagine how the low temperature may be further reduced in the future. The jet type of condenser was once quite common, but since the demand for pure feed-water became insistent the surface type has been almost universally used in large plants.

During the period under consideration, superheated steam has been in almost universal use. As pressure drops in the turbine the superheat is lost and the steam becomes wet. Since steam temperatures over 800 deg are seldom used, the steam becomes wet long before it reaches the exhaust in high-pressure turbines. A decided gain in efficiency may be obtained by reheating the steam at some stage or stages in its passage through the turbine. If heat from the products of combustion is used—and about 80 per cent of the plants where reheating is employed use this method—the steam is taken from the turbine casing at the proper pressure stage and led to the furnace where it is reheated to approximately its original temperature. It is then brought back superheated to the turbine and finishes its work there. The objection to reheating is the more complex equipment required and the consequent increase in both first and maintenance costs. In many of the newer plants, however, it has been shown that reheating materially increases the total economy. Naturally the most favorable results are obtained in the high-pressure plants.

For the past several years, practically all new plants have been designed to bleed steam at from three to five pressure-stages of the turbine, and to use the steam thus bled to heat the feed-water. This process has a dual advantage—first, it increases the efficiency of the heat cycle, and second, it simplifies turbine design by reducing the volume of low-pressure steam that must be accommodated in the last stages of the turbine.

MISCELLANEOUS TRENDS

The idea of a binary cycle, in which more than one medium is used, is not new, but no successful commercial application of any magnitude was made of it until quite recently. Several media have been proposed, but mercury seems to be the one best suited to the purpose. There are now in use in this country three mercury-steam plants, and reports indicate that they are operating successfully. Whether the binary cycle for commercial plants will become common in the near future appears to be largely an economic problem. In this type of plant there are a mercury boiler, mercury turbine, and mercury condenser. The mercury condenser is a heat-exchanger which acts as a steam boiler. The steam generated is used in a steam turbine and is condensed in the conventional manner. The pressure-temperature relationship of boiling mercury is such that relatively high temperatures may be used with fairly low pressures; hence the mercury-steam combination gives the advantage of a large temperature range without the disadvantage of exceedingly high pressures. Overall net thermal efficiencies of about 34 per cent have been obtained with this scheme.

During the past 15 years the metallurgist has made remarkable advances in his art. This is reflected in the materials from which boilers, turbines, and other equipment are constructed. Alloys to withstand higher temperatures, corrosion, and erosion, are used in turbines as well as in boilers and piping. For many years, welding was frowned upon for use in high-pressure boilers. With the improved welding techniques recently acquired, however, the methods of fabrication of the boiler and piping have undergone marked changes.

In the past, the cost of the building to house the power plant has been a very large item in the total cost. Proposals have recently been made to reduce or almost entirely do away with the building. With the elimination of man-power in the plant, it may be entirely feasible to put the plant out in the open.

Interconnection of plants and increased mechanical dependability of equipment have produced a considerable decrease in the standby or reserve equipment thought necessary. In a good plant, at present, the various pieces of equipment are capable of being used from 80 to 90 per cent of the time. It would appear that the ultimate in plant efficiency and economy has not been reached, although it can hardly be expected that in the future there will be as rapid an increase in efficiency as has taken place in the immediate past. Our best plants today are capable of producing a kilowatthour with the expenditure of but little more than 10,000 B.t.u.

A Modern Diesel-Engine Central Station

Municipal Plant in California Illustrates Applicability of Diesel Power to Large Loads

By Howard McCurdy

Associate Member American Society of Civil Engineers
City Engineer, Vernon, Calif.

Steam and hydro-electric plants no longer have the large power markets indisputably to themselves; the Diesel engine has proved itself a worthy contender for continuous, peak-load, or standby service. At Vernon, Calif., the second largest Diesel plant in the world has been in operation for two years, carrying a heavy industrial load. This article, describing the Vernon installation, is abstracted from a paper presented by Mr. McCurdy on July 4, 1935, before the Power Division of the Society at the Los Angeles Convention.

The 37,500-kva municipal plant at Vernon, Calif., is the second largest Diesel installation in the world. Its total net power output in the past fiscal year placed it in second position among municipal plants of all types in California. From studies made of other plants and the experience gained in operating this one, I am firmly convinced that the Diesel engine is an economical and reliable prime mover for continuous, peak-load, or standby service, and is entitled to serious consideration.

A plan and cross section of the Vernon plant are shown in Figs. 1 and 2, in sufficient detail to make clear the general arrangement of both mechanical and electrical equipment. The station is equipped with five two-cycle, double-acting, 8-cylinder, mechanical-injection Diesel engines (constructed by the Hooven, Owens, Rentschler Company), each rated at 6,850 bhp. These are the largest in the United States. Each generating unit is 56 ft long and 24 ft in height above the floor, with foundations extending 12 ft below. The cylinder bore is 24 in., and the stroke 36.

Eight double-acting cylinders are equivalent to 16 single-acting cylinders, as each piston receives one power impulse at the top of the cylinder and another at the bottom. Oil is pumped at 5,000-lb pressure to each cylinder just before its piston reaches dead center. Ignition is caused by the high pressure of the compressed air. The compression pressure of 425 lb per sq in. is raised by combustion to about 600 lb per sq in., causing an initial total pressure of 271,200 lb—134 tons—to be exerted on the piston. Two cylinders fire at a time, and the engines operate at 167 rpm. Both cylinders and pistons are water cooled.

An auxiliary control panel is located at each engine. This enables the operator to start by push buttons all auxiliary equipment for that unit—pumps, blower and centrifuge, cooling tower, heat-exchangers, circulating water, and blower motor-operated valves. Signaling equipment, pyrometers, thermometers, and flow gages are also located here.

Of the total energy derived from the fuel, 36.3 per cent is recovered in useful work, 26 per cent is lost to cooling water, 33.7 per cent to exhaust gases, and 4 per cent to friction and radiation. Part of the exhaust heat is recovered by waste-heat boilers in the form of steam for double-effect evaporators, which distil the cooling water.

Fuel has ranged from 20.5 to 27 deg gravity (American Petroleum Institute standard). The average of oil used last year was 25.4 deg gravity (A.P.I. standard). Saybolt viscosity at 100 F averaged 69 sec; Conradson carbon by weight, 0.40 per cent; and flash point, 210 F. Average fuel consumption is indicated in the accompanying Table I.

Generators and Regulating Devices

Direct-connected to each Diesel engine is an Allis Chalmers 7,500 kva, 7,200-v, 3-phase, 50-cycle generator, with a 70-kw, 250-v, shunt-wound main exciter and a 4-kw compound-wound pilot exciter on an extension of the same shaft. Each generator is totally enclosed, and cooled by air in

Table I. Average Fuel Consumption at Various Loads

How Measured	Load			
	One-quarter	One-half	Three-quarters	Full
Gross, lb per bhp hr	0.454	0.376	0.362	0.355
Net, lb per bhp hr	0.562	0.418	0.388	0.380

a closed system forced through the machine and air-coolers by fans attached to the rim of the rotor spider. In the following cases the efficiency guarantees were: for one-quarter load, 91.5 per cent; for half load, 94.5 per cent; for three-quarters load, 95.4 per cent; and for full load, 95.75 per cent.

As a change in load necessarily causes a variation in speed before the governor can act mechanically, instantaneous frequency-control to act electrically was

The Municipal Power Plant at Vernon, Calif.
This Attractive Steel-and-Concrete Building Is Finished in Mission Stucco

installed. In response to a change in frequency, the controller causes the governor motor to make a correcting change in the setting of the fuel-pump by-pass valve. The controller includes an impedance bridge as the fre-

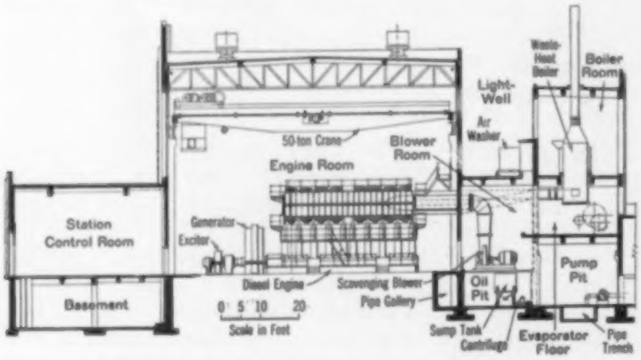


FIG. 1. SECTIONAL ELEVATION, UNIT NO. 4

quency-sensitive element to govern the action of the control mechanism. The bridge can be set to control at any frequency between 49.75 and 50.25 cycles; a departure of 0.01 of a cycle from the bridge setting will cause the controller to send a corrective impulse to the governor motor.

Superimposed on the frequency control, a master clock compares the system's electric time with pendulum time, and any differential between them will change the balance point of the bridge in the frequency controller so that the frequency is maintained slightly above or below 50 cycles until the electric time is corrected to pendulum time.

Any one of the five engines can be selected for master frequency-control while the other units operate under individual proportionate or base-load controllers, which assist the master unit by proportioning the loads of the respective engines. There are anticipatory and filtering relays to prevent "hunting."

Generator voltage is controlled by varying the field of the main exciter through a motor-operated field rheostat, thereby eliminating the generator field-rheostats. The voltage regulator is designed to respond to slow voltage changes of plus or minus 0.5 per cent or greater. On abrupt voltage changes of 3 per cent or greater, high-speed relays are brought into action to remove or insert full resistance in the main exciter field circuit in 3 cycles.

The auxiliary equipment is largely individual, so that each prime-mover unit is practically complete in itself. The more important auxiliaries are described briefly in the following paragraphs.

IMPORTANT AUXILIARY EQUIPMENT

Combustion air passes through scrubbers into the blower rooms. Individual centrifugal blowers with open-end suctions, driven at 2,950 rpm by a 400-hp, squirrel-cage induction motor, deliver 27,000 cu ft of air per minute, at a pressure of 2 lb, to each engine. A motor-operated, butterfly-type gate valve on the blower discharge is closed to allow starting under no load.

Each engine has two centrifugal pumps for cooling water connected to one 50-hp induction motor. One—a 5-in. pump—delivers 770 gal per min at an 80-ft head, 500 gal per min for the cylinders and oil cooler and 270 gal per min for the condenser; the other—a 4-in. pump—delivers 480 gal per min at 110-ft head, 370 gal per min for pistons, and 110 gal per min for generator cooling. The cooling-tower pumps, each driven by a 40-hp induction motor, deliver 1,750 gal per min at a 70-ft head. The total of 1,250 gal per min of pure water per unit is circulated in a closed system through heat-exchangers, on the other side of which 1,750 gal per min of raw water is passed for conveying heat into the atmosphere at the cooling towers. While operating, each unit requires a total of 4,320,00 gal per day of pure raw water.

Cooling towers are of the forced-draft type with motor-driven fans. Considerable saving in space and pumping head was obtained by the use of this type of tower, although the saving is partially offset by the power required to drive the fans. However, the fans give complete control of water cooling, and it is not necessary to depend on the weather, which is apt to be unreliable. The tower fans furnish 300,000 cu ft of air per minute to cool the water of one generating unit.

Each engine has two exhaust headers—one each for the upper and lower cylinders—which are connected to separate muffling-type waste-heat boilers, designed for 100-lb gage working pressure, and to recover 62 per cent of the exhaust heat, at 50 lb absolute pressure with an engine load of 87.5 per cent. The exit temperature of gases is 360 F.

The double-effect evaporators were designed for normal operation with four engines. Water from the city

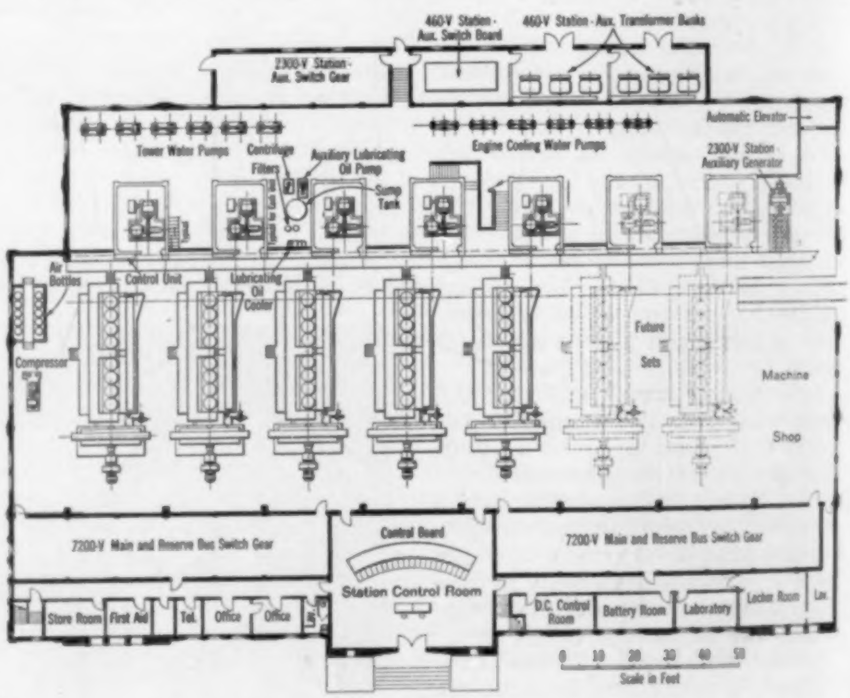


FIG. 2. GENERAL ARRANGEMENT OF MAIN FLOOR
Provision Has Been Made for Future Enlargement

system passes through a condensate heat-exchanger to a de-aerating heater and storage tank, whence it is pumped to the evaporators. Condensate from the evaporators and condenser flows by gravity from the flask tank through the heat-exchanger to the engine circulating-

water storage basin. Boiler condensate is pumped back to the boilers in a closed system.

Lubricating oil for bearings is handled in individual external systems. It drains from the crank case to a cone-bottomed sump tank for 5-min retention to help settle impurities. From this it is pumped by the attached engine pump at the rate of 200 gal per min, through two oil filters and the oil cooler, back to the engine bearings. A centrifuge to clean the oil takes suction from the bottom of the sump tank and returns oil to the top of the tank. The oil is heated by steam from the evaporators before centrifuging.

Lubricating oil for cylinders is pumped from bulk storage to a roof tank, whence it is piped by gravity to the lubricators on the engines.

Fuel oil, received by tank cars and trucks, is pumped through meters to a storage system consisting of 10,000, 15,000, and 25,000-bbl tanks. Centrifuges with attached pumps draw oil from these tanks, clean it, and pump it to the elevated day-tanks. The oil then flows from each tank by gravity, through a separate filter and meter.

For starting the auxiliaries in emergencies, there is installed a 12-cylinder, 550-hp gasoline engine, direct-connected to a 2,300-v, 500-kva alternator with overhung exciter. When necessary, this unit will supply energy to start and run the blower, circulating-water pumps, and valve motors for one unit, and will energize the transformer banks. After one Diesel unit is up to speed, it is synchronized with the emergency set and the latter is dropped from the line.

ELECTRICAL FEATURES

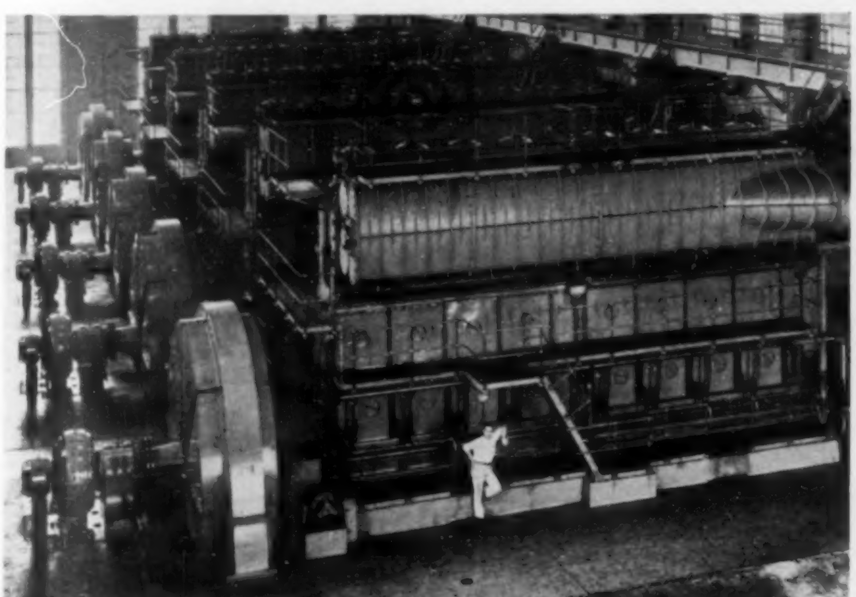
The control board, with bench and vertical instrument board, is constructed in an arc concave to the main entrance. The bench section is provided with a complete miniature bus in single-line form. An aisle back of the control board separates it from a parallel, vertical, relay board with the instruments mounted on the convex side in the back. The panels are of ebony-asbestos finished with polished black lacquer and mounted on a steel framework. Invisible fixtures diffuse light through glass panels in the ceiling. The entire electrical system is controlled from this room.

Totally enclosed, metal-clad, 15-kv switchgear units, operated at 7.2 kv, are housed in two separate rooms, one on each side of the control room. The connecting overhead bus is also totally enclosed, and provided with sectionalizing breakers. To avoid extensive changes in the future, the main bus is designed for an ultimate generating and tie-line capacity of 75,000 kva, and all switchgear units are designed to successfully rupture 22,000 root-mean-square amperes with sustained voltage on the bus. The main and reserve bus are connected together by individual generator breakers, and to the feeders by single breakers with transfer plugs. By-pass switches and disconnectors allow a breaker to be dropped for servicing. Feeders leave the station by cable in an underground conduit system and rise to aerial construction on streets a block or two away.

An Aerial View of the Vernon Plant

Station-auxiliary switchgear equipment is housed at the rear of the plant, one room containing the 2,300-v, metal-clad equipment and another the 460-v equipment. Duplicate sets of transformers are provided with automatic transfer switches.

The station-lighting and d-c control-board is installed in a separate room adjacent to the main operating room. Lighting current can be supplied either from the main station bus or, in emergency, from the station control battery. The transfer is automatic. Control equipment is also on the board for battery-charging equipment consisting of a 5-kw, 125-v, motor-generator set. A special power panel provides connections to convenient terminal outlets located throughout the power house, which can be energized by the use of transfer plugs to supply 110, 220, or 460-v single-phase and three-phase alternating, and 125-v direct current. The station control battery is the 240-amp-hr, 60-cell, 125-v, Planté type.



Diesel Engines, Alternators, and Exciters
The 6,850-bhp Engines Are the Largest of Their Type in the United States

The Vernon station was designed and constructed under my direction as city engineer, with the following organization: Wayne N. Johnson, in charge of electrical design; J. S. Colton, in charge of structural design; and H. A. Thalimer, Assoc. M. Am. Soc. C.E., in charge of piping design. C. A. Heinze acted as consulting electrical engineer, and F. L. Roehring as consulting architect.

OUR READERS SAY—

In Comment on Papers, Society Affairs, and Related Professional Interests

Closure of Discussion on Concrete Design for Bending and Direct Stress

To the Editor: Mr. Eckles' discussion of my article, entitled, "Concrete Design for Bending and Direct Stress," in the October 1934 issue of Civil Engineering, was noted with interest. This criticism, which appeared in the February 1935 number, was

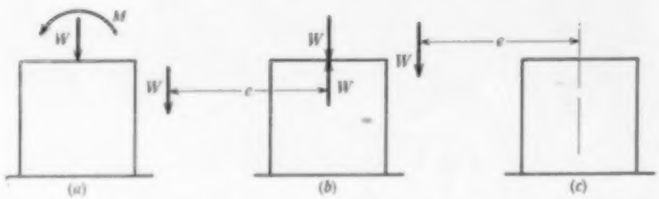


Fig. 1. Resolution of Axial Thrust and Bending Moment

based upon a fundamental error in Mr. Eckles' equations. My method has been thoroughly checked, and all discussions of it but Mr. Eckles' have agreed as to its correctness. He says that my equations do not contain a term that "includes direct compression on the cross section, the thrust, N, being used only in the term for moment Ne_1." That this conception is in error can easily be demonstrated. The axial thrust and bending moment are shown in Fig. 1(a). By defining e as M divided by W, the moment, M, can be expressed as two forces of equal magnitude, W, and distance, e, apart forming a couple, Fig. 1(b). There are now two axial forces of equal magnitude and opposite in direction which cancel, giving the resultant force system shown in Fig. 1(c).

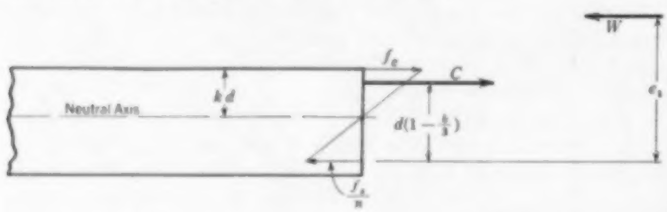


Fig. 2. Diagram Using the Eckles Nomenclature

Also Mr. Eckles says, "in the [Eckles] nomenclature W is substituted for N, and M is used for Ne_1." This leads to Fig. 2. Mr. Eckles uses the condition that the summation of the horizontal forces must be zero to obtain $C = W + A_sf_s$. He then determines an expression for A_sf_s by a procedure that should recognize the equality of internal and external moments. On taking moments about a point $kd/3$ down from the compressive surface, he gets the equation $A_sf_s(1 - k/3)d = M = We_1$. The correct and general formula is $A_sf_s(1 - k/3)d = W[e_1 - (1 - k/3)d] = M - W(1 - k/3)d$. This fundamental error is carried through Mr. Eckles' entire criticism. The scope of my method has been proved to include tee beams and compression over the entire face.

Adolphus Mitchell, Jun. Am. Soc. C.E.
Structural Designer

Santa Fé, N.M.
August 8, 1935

Another Tilting Glass Flume in Use

To the Editor: In their article, "Tilting Glass Flume Demonstrates Value," in the June issue, Messrs. Bentzel and Tiffany state, "As far as the writers know, however, only one other installation, the Hydraulic Structures Laboratory of the Royal Technical University at Stockholm, Sweden, has combined in one structure the advantages of glass sides with those of a tilting mechanism."

I wish to call attention to the tilting glass flume which has been in use for thesis investigations at the Hydraulic Laboratory of the University of California since 1929. It is 24 ft long, 6 in. wide, and 16 in. deep, with a maximum slope of 0.0464. It is provided with an upstream stilling basin and a sand trap at the downstream end. The slope is changed with a manually operated screw-jack. The panels are 2.9 by 1.2 ft, with $^1/_4$-in. thick glass.

Also, the U. S. Tidal Model Laboratory at the University of California has a tilting flume 43 ft long, 1.5 ft deep, and 3 ft wide, which contains glass inspection panels. These panels are 3.5 by 1.5 ft and allow observation similar to those in a complete glass flume. This flume was built in 1934, and there are others of the same type in use in this country.

Both flumes were designed and constructed under the supervision of M. P. O'Brien, Assoc. M. Am. Soc. C.E., the head of the laboratories.

Richard G. Folsom
Instructor in Mechanical Engineering
University of California

Berkeley, Calif.
July 22, 1935

A General Method for Solving Cubic and Other Equations

To the Editor: The methods of solving cubic equations presented from time to time in Civil Engineering are very interesting, but most of them require more familiarity with mathematics than the method that I am presenting, which is sometimes called "approximation by double position." This method is not limited to cubes, nor does it require the use of a specially constructed slide rule. It can be applied to transcendental or algebraic equations in general. It can be made partly graphical, but does not require extensive plotting. It is illustrated by the solution of the equation solved previously by Mr. Fischer in the April issue, $x^3 - 12x^2 + 45x - 53$.

Let $y = x^3 - 12x^2 + 45x - 53$. If positive and negative integral values are assigned to x, and corresponding values of y are computed, the following table results:

x	y	x	y	x	y
−2	−199	2	−3	6	1
−1	−111	3	1	7	17
0	− 53	4	−1	8	51
1	− 19	5	−3	9	114

The curve, if plotted, would cross the x-axis where a change of sign occurs in y, namely, between 2 and 3, 3 and 4, and 5 and 6. That is, y will equal zero, and a root of the equation will be found between each of these pairs of values. One root is therefore 2 plus a decimal. To find approximately the first decimal figure, we note that as y moves from -3 to $+1$, x increases by unity. Therefore we assume that to make y equal to zero, x moves to the right three-quarters of a unit. Substituting 2.75 in $y = x^3 - 12x^2 + 45x - 53$ gives y a positive value. Since this is the same sign as that previously obtained by substituting for x the greater of the two integers between which the root lies, the value is too large. It is necessary to continue until a change of sign occurs. The next try of 2.5 gives a value of $+0.125$ to y, while 2.4 gives a value of -0.296. Therefore 2.4 is the value of the root to one decimal place. Continuing by the same method to the next decimal place gives $x = 2.47$. The other two roots are similarly found to be $+3.65$ and $+5.88$.

Leo T. Tyburski, Jun. Am. Soc. C.E.

Wilkes-Barre, Pa.
August 10, 1935

Closure of Discussion on Pole Embedment

Dear Sir: In the May issue Mr. Appleford discussed my article on "Embedment of Poles, Sheeting, and Anchor Piles" that appeared in December 1934. He outlined a method of computing pole anchorage which assumes that the wedge of earth disturbed by a horizontal movement of the pole is fan-shaped in plan. My agreement with this view is shown in the reference, on page 626 of my article, to diverging shear planes. Mr. Appleford's assumption and method are incomplete, however, for they do not permit the shape of the pole to be taken into account. Experiments show that a circular pole develops a much greater passive soil resistance than a square-cut pole of width equal to the diameter of the round one.

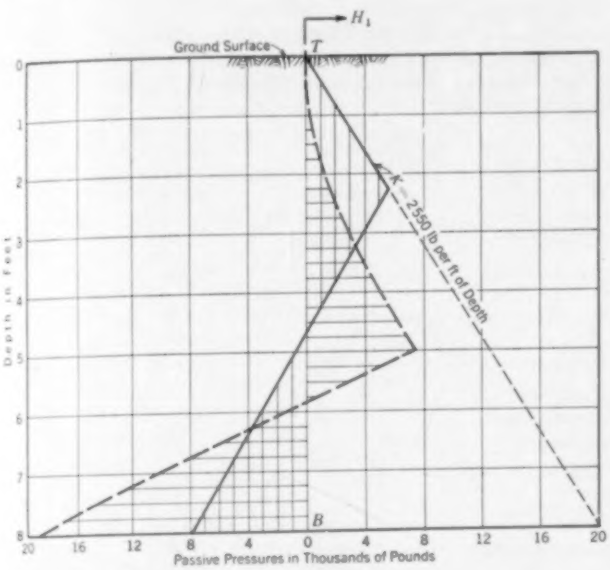


Fig. 1. Comparative Passive Pressures for Pole Embedded 8 Ft

A comparison of the distributions of passive resistance for a pole embedded 8 ft, as obtained by the two methods, is shown in Fig. 1. Mr. Appleford's distribution diagram (from his Fig. 2) is indicated by horizontal hatching, and my diagram for resistance for the same moment (65,000 ft-lb from his Fig. 3) is shown by vertical hatching. The latter distribution was obtained by using a K value of 2,550 lb. In part, the difference in the pressure distributions may be accounted for by the fact that Mr. Appleford evidently assumed the soil to have an angle of repose, or of internal friction, of 30 deg. This would be a suitable value for a loose granular mass but not for a virgin soil or well-consolidated fill. My value of K was derived from $K = 1{,}000 + 100\ d$, taking 15.5 as the average diameter of the embedded 8 ft. The expression $K = 1{,}500 + 150\ d$, presented in my article, was for a compact clayey soil. Later analyses of poles embedded in average soils indicated that for such cases the constant of 1,000 and a coefficient of 100 should be used.

A comparison of the factors of safety indicated by the two methods is interesting. An 8-ft depth of setting is standard for a 60-ft pole. The force required near the top of such a pole to cause an overturning moment of 65,000 ft-lb is about 1,100 lb. As the specified test load for an average (Class 3) pole is 3,000 lb, the factor of safety for the pole itself, with a 1,100-lb load, is nearly 3. However, according to Mr. Appleford's method, the passive resistance pressures in his diagram are the maximum that could be attained, and the factor of safety of the anchorage would therefore be only 1. In my method, on the other hand, the pressure distribution indicated by the vertical hatching in my diagram corresponds to an anchorage factor of safety of about 3, the same as that for the pole. Also, the pressure distribution as given by the horizontal hatching would indicate a condition in which the pole could not be expected to regain its original vertical position when the force ceases acting.

If special anchorage—concrete blocks or timber logs—were provided, the required lengths of members, as computed by the two methods, would be very different. If timber logs were placed 1.5 ft below the ground surface in front of the pole and 1.0 above the butt at the back of pole, the required length of the former as compared with the latter would be in the inverse ratio of the unit pressures at these points. Thus, using Mr. Appleford's pressure distribution, the upper log would have to be $\frac{10{,}000}{700}$, or 14 times as long as the lower one, while for my pressure distribution this ratio would be $\frac{5{,}400}{3{,}800}$, or 1.4. The latter ratio agrees closely with the ratio of the lengths of such logs in actual use.

Mr. Appleford states that he found the resisting moments to vary nearly as the fourth power of the depth of embedment, instead of as the third power as given by me. However, the required depths of setting for a given moment, obtained by the two methods, do not differ greatly. In my method, using a resisting-moment coefficient of 0.042 (which provides a factor of safety of about 3.5) and K-values as previously indicated for an average soil, depths of 4.7, 8.4, and 11.0 ft were obtained compared with 5.0, 8.0, and 10.0 given on Mr. Appleford's Fig. 3.

M. A. Drucker
Designer in Charge, Board of Transportation

New York, N.Y.
Aug. 3, 1935

Solution of Cubic Equations Corrected

To the Editor: In my letter to the editor, entitled "Simple Solution of Cubic Equations," in the August 1935 issue, I note a typographical error in the last sentence of the paragraph before the last. This sentence should read "Other real roots of the equation can be found in a similar manner or by dividing the original equation by z minus the root found, and operating on the resulting equation as desired." A comma appeared in place of the word "minus."

Francis L. Castleman, Jr., Assoc. M. Am. Soc. C.E.

Philadelphia, Pa.
August 12, 1935

New Tables for Fixed-End Moment Coefficients

To the Editor: It has been recently called to my attention that a set of tables somewhat similar to those in my article in the December 1934 issue, in "Engineers' Notebook," appear in Chapter IV, Table II, of *Statically Indeterminate Stresses*, by Parcel and Maney.

The tables referred to give values of the coefficient $A = x^2 - x^3$ for 18 or 20 values of x included in my tables, plus the values of A for about 20 intermediate fractional values of x ($^1/_8$, $^2/_9$, $^3/_7$, etc.) not reducible to decimals of even hundredths, and thus not included in my tables.

In addition, the authors include values for the coefficient $D = \frac{x^3}{3} - \frac{x^4}{4}$, which I mentioned in my article, but stated that a table was not necessary as D could be determined from the coefficient $C = {}^1/_2x^2 - {}^2/_3x^3 + {}^1/_4x^4$. The values for C are not included in the Parcel and Maney tables. They also include two other sets of values of coefficients for use with triangular loadings, varying uniformly from zero at one end to a maximum at the other, or for portions of such loading.

In the explanation of their tables, the authors derive the various algebraic functions of x (or k, as used in their notation). Such derivations should possibly have been included in my article. These various tables make a very complete set, and with them it is possible to determine, with a minimum amount of computation, the fixed end moments in a beam of uniform cross section, for all the various types of loading covered by them.

L. K. Oesterling
Aluminum Company of America

Pittsburgh, Pa.
August 6, 1935

SOCIETY AFFAIRS

Official and Semi-Official

Pros and Cons of the Proposed Amendments

Committees Appointed at Los Angeles Convention Present Arguments For and Against Changes in Membership Grades

TWO PROPOSED AMENDMENTS to the Constitution are before the members for adoption or rejection. Proposal No. 1 would revise membership grades by designating Corporate Members as Fellows and Members. A Fellow "shall have been a Member of the Society for not less than five years and shall have been engaged in the active practice of his profession for not less than twenty-five years and for at least ten years thereof shall have been responsibly engaged in work of substantial importance requiring engineering ability of a high order. . . ." A Member . . . "shall have had responsible charge of work as principal or assistant for at least one year, and shall have been in the active practice of his profession for at least eight years, and shall be not less than twenty-seven years of age." The grade of Associate Member will be eliminated. Proposal No. 2 relates to the manner of publication of the list of Official Nominees, permitting it to appear in CIVIL ENGINEERING instead of in PROCEEDINGS. Pros and cons of Proposal No. 1 are presented in the accompanying article.

Ballots on the proposed amendments to the Constitution were mailed on August 16 to all Corporate Members of the Society, and will be canvassed on October 16 at a regular business meeting of the Society called solely for that purpose.

The August issue of CIVIL ENGINEERING published the proposed amendments as modified at the Annual Convention at Los Angeles. At that Convention it was also voted that when the ballots on Proposal No. 1 (concerning changes in membership grades) were issued they should be accompanied by statements as to the reasons for adoption, and the reasons against adoption. President Tuttle appointed as a committee to prepare the statement giving reasons against adoption, J. C. Stevens, chairman, Henry D. Dewell, and J. D. Galloway; and as a committee to prepare the statement giving reasons for adoption, J. P. H. Perry, chairman, F. A. Barbour, and Frederick H. McDonald. The reports of these committees, presented in full in the pamphlet accompanying the ballots, are abstracted here.

STATEMENT AGAINST ADOPTION OF PROPOSAL NO. 1

Against the adoption of Proposal No. 1 the following objections were adduced:

"The pertinent points of the proposed amendments that require consideration are:

"1. The new grade of Fellow. He shall have held the grade of Member for 5 years, shall have practiced for 25 years, and for 10 years shall have been in 'responsible charge' of work. All Members who now meet those requirements are automatically advanced to the grade of Fellow.

"2. Reduction of the qualifications for Member to that now specified for Associate Member.

"3. Elimination of the grade Associate Member.

"This committee believes that the amendments in their present form should be voted down for the following reasons:

"The four Founder Societies now have radically different qualifications for their Membership grades. If the recommended changes be adopted even the names of the grades will not be entirely uniform and the qualifications must still remain hopelessly confused. At present only the Civils and Mechanicals are proposing amendments. In addition to the grade of Fellow and Member, the Mechanicals retain the grade of Associate (a quasi non-engineering grade), which the Civils do not and will not have.

"The following table shows the essential qualifications and designations of the grades above Junior, present and proposed, for the four Founder Societies. All those in the present grade of Member who are not transferred to Fellow will be reduced to the grade of Associate Member, even though they retain the title Member.

"The qualifications for the Corporate Members of this Society are considerably higher than for any of the other founder Societies. The proposed amendments would seem to lower those standards instead of raising them—it certainly lowers the present grade of Member materially.

	Am. Soc C.E.		A.S.M.E.		A.I.E.E.	A.I.M.E.
	Present	Proposed	Present	Proposed	Present	Present
Fellow:						
Minimum age.....	See text	40 yrs.	no rating	40 yrs.	32 yrs.	no rating
Active practice....	See text	25 yrs.	no rating	25 yrs.	10 yrs.	no rating
Responsible charge	See text	10 yrs.	no rating	not fixed	3 yrs.	no rating
A member for.....	See text	5 yrs.	no rating	13 yrs.	not fixed	no rating
Member:						
Minimum age.....	35 yrs.	27 yrs.	32 yrs.	30 yrs.	27 yrs.	27 yrs.
Active practice....	12 yrs.	8 yrs.	10 yrs.	9 yrs.	5 yrs.	6 yrs.
Responsible charge.	5 yrs.	1 yr.	5 yrs.	3 yrs.	3 yrs.	3 yrs.
Associate Member:						
Minimum age.....	27 yrs.	no rating	27 yrs.	no rating	no rating	no rating
Active practice....	8 yrs.	no rating	6 yrs.	no rating	no rating	no rating
Responsible charge	1 yr.	no rating	2 yrs.	no rating	no rating	no rating
Associate, age.......	no rating	no rating	30 yrs.	30 yrs. (non-engineering grade)	21 yrs. (non-engineering grade)	not over 27

"The grade for which Fellow is proposed should be universally recognized to carry with it the distinction of exceptional accomplishment, but 'fellow' does not always convey that impression. In earlier English it designated 'a man without good breeding or worth'—Webster. 'Worth makes the man, the want of it the fellow.'—Pope.

"While it is true that in recent times the term has acquired a kinder and more distinguishing meaning as used by scientific societies, the layman does not appreciate these niceties, and the avowed purpose of the amendments is, therefore, not likely to be realized.

"To most of us the term 'fellow' is an academic one; a student who remains in college to teach and earn his living while he pursues advanced studies. It has a pedagogic slant—sort of impractical and brain-trusty.

"This Society already has a grade of Fellow—anyone who will contribute $250 to the funds of the Society may become one—no other qualifications necessary.

"Transfer to any higher grade should be made on merit through the scrutiny of professional records, not by such mass transfers as these amendments propose. Grades so filled never rise above their origin.

"The adoption of these amendments will admit to the grade of Fellow a goodly number whose activities have not been in engineering for many years, such as salesmen, bankers, merchants, administrative officers, etc., and would raise to the grade of Member a great mass of such in non-engineering fields. If a higher grade is to be added, let it be attained on individual merit, not by mass transfer, and without disturbing the existing steps that have evolved through 83 years of dignified existence.

"The grade of Associate Member by whatever name it may be

called is a most appropriate step in the civil engineer's ascent to achievement and it should not be eliminated.

"If objection is had to the term 'Associate Member'—and objection to it has been raised—it is suggested that further study be given this matter and a more suitable name found.

"The disadvantages of the amendments proposed greatly outweigh the advantages. Uniformity of name is of no value without uniformity of substance. Reduction in rank of several thousand Members is ruthlessly unfair to them and entirely unnecessary. The term 'Fellow' is a misnomer. Elimination of the grade of Associate Member is like removing the keystone.

"If a different and more consistent set of terms is desired for the several membership grades, a discussion should be opened in CIVIL ENGINEERING, and Local Sections should be consulted before submitting amendments for final action with a take-it-or-leave-it gesture."

Statement in Favor of Adoption of the Proposed Amendments for Changes in Membership Grades

In favor of the adoption of Proposal No. 1 the following report was presented:

"The Engineers' Council for Professional Development in June 1934 recommended to the Board of Direction of our Society that it adopt uniform grades of membership. The Board in July that year appointed the signers of this statement a committee to study the matter. At the April 1935 meeting of the Board this committee's report was adopted unanimously, and substantially all the members of the Board of Direction are endorsers of the petition for constitutional changes to put into effect the Committee's recommendations.

"E. C. P. D. bases its recommendations that the four Founder Societies adopt uniform grades of membership on the following:

"1. The present measures for the recognition of the qualified engineer in the United States are most confusing.

"2. The grades of members in the various professional societies are not uniform in name or in the required attainments.

"3. Although a uniform law for licensing has been agreed upon, the existing laws in the 28 states have different requirements. The process of changing them is necessarily slow but must go on—and progress cannot be satisfactory in face of such utter lack of uniformity within the Founder Societies as now prevails.

"4. Exhaustive study of the requirements leads to the conclusion that the profession should agree upon a uniform definition of the engineer as the basis of all schemes of recognition, and upon uniform grades of membership.

"E. C. P. D. specifically recommends the following designations and brief specifications:

"*Student Member*—A person matriculated in an approved school or pursuing studies in accordance with the program of the Committee on Professional Standing of E. C. P. D.

"*Junior Member*—A graduate of an approved school or one who has passed the equivalent written and oral examinations.

"*Member*—A full-fledged engineer, that is, the engineer who has passed the requirements in the minimum definition of an engineer.

"*Fellow*—The mature engineer who has achieved distinction.

"These grades are in accord with the four logical steps in the engineer's development to professional maturity. The first step is that of the student; the second, that of the engineer in training, or Junior; the third is the fully qualified entry into the profession itself, that is, the attainment of all the qualifications and the recognized standing of an 'Engineer' (including readiness for registration), when he may be designated as a 'Member'; and the fourth is the point in an engineer's career when his achievements entitle him to a position of distinction in his field, and the designation 'Fellow.'

"As to the proposed dropping of the grade of 'Associate Member' and the transferring automatically of all those in that grade to the new grade of 'Member' it may be pertinent to ask 'What is an Associate Member?' In many organizations the prefix 'associate' denotes 'non-active,' 'contributing,' 'non-technical,' 'sustaining,' etc., etc.

"An earlier movement within our Society to drop the Associate Member grade and add a new senior grade culminated in 1929–1930. . . . A questionnaire was sent to the Corporate Membership, and replies were received from 37.3 per cent thereof, or from 4,364 Corporate Members; 63 per cent of the replies expressed approval of membership designations of 'Junior Member,' 'Member,' and 'Fellow' or 'Member Senior Grade.' In other words, 63 per cent of those replying to the questionnaire were agreeable to the elimination of the 'Associate Member' grade.

"Although the returns from the questionnaire indicated receptivity on the part of the membership to the proposed new grading of membership, the then Board of Direction of the Society determined against recommending such changes at that time.

"In the six years which have elapsed it is common knowledge that fundamental changes have occurred and major new problems affecting the professional standing and future of our membership have arisen.

"The Engineers' Council for Professional Development was organized about three years ago to attempt to solve some of these problems for the whole engineering profession. Its work to date unquestionably merits the confidence and the support of our members. Substantially all the recommendations it has made to our Society have been approved, as witness the approval by our Board of Direction of its Minimum Definition of an Engineer. The Am. Soc. C.E. cannot afford to fail to support E. C. P. D. in a major recommendation such as the one here under discussion.

"Obviously should the 'Associate Member' grade be dropped it becomes necessary to create a senior or higher grade of membership to take care of those who are now full members of the Society and who constitute the senior and more experienced group.

"The returns from the questionnaire in 1929–1930 showed that 1,888 of the Corporate Members were in favor of the term 'Fellow' as against 869 favoring the term 'Member Senior Grade.'

"The grade of 'Fellow' in scientific and engineering societies in Great Britain and Europe has received high acknowledgment for many years. In English and American universities, the term 'Fellow' is in wide use and implies distinction. The American Institute of Architects, the American College of Surgeons, the American Physical Society, the American Association for the Advancement of Science, and the American Institute of Electrical Engineers have the grade of Fellow for those members who have attained distinction.

"What will be the effect on the membership if the amendments are approved so far as the new grades of 'Member' and 'Fellow' are concerned?

"The following figures are taken from the 1935 Year Book:

"If the amendments prevail, the 6,097 'Associate Members' will become 'Members.'

"Studies have been made by the office of the Secretary of the effect of the amendments on those occupying the present 'Member' grade. It appears that of the 5,683 'Members,' 4,906 will automatically become 'Fellows.'

"This means that about 777 present 'Members' may remain in that grade pending such time as they can qualify for the grade of 'Fellow.' Since, however, the grade of 'Fellow' is not in any way closed to these members, but to the contrary can be achieved in a normal and natural manner, the equity and fairness of initiating

In This Issue . . .

FALL MEETING of the Society in Birmingham, Ala., October 16–19, 1935

the new grade under these conditions is obvious. While some present 'Members' will remain as such they will be the seniors in the new grade of 'Member' and will have the privilege of welcoming into this grade all those who only by the proposed constitutional change can get rid of the awkward misnomer 'Associate Member' which has heretofore been so non-descriptive of their actual technical status.

"While it is true the adoption of these amendments will not at once result in the uniformity which is the goal of E. C. P. D., it cannot be denied a real step in the right direction will have been taken.

"There is no lowering of our standards. The requirements for the new grade of 'Member' are identical with those of the present 'Associate Member' grade. The new grade of 'Fellow' requires 25 years active practice as against 12 years for the present 'Member' grade. A 'Fellow' must have had 'responsible charge' for at least 10 years as against the 5-year requirement for the present grade of 'Member.'

"What these proposed amendments accomplish in general is to make it easier for a full-fledged engineer (one who is eligible for registration), to become a 'Member' of the Society and to make it more difficult, particularly in the future, to attain the senior or distinguished membership grade, namely, that of 'Fellow.' Twenty-five years versus 12 years of 'active practice' and 10 years versus 5 of 'responsible charge' are a clear step forward in the raising of the senior grade of membership of our Society to even more preeminence than it now enjoys."

CONTENTS OF "PROPOSAL NUMBER TWO"

Proposal No. 2, on which there was no adverse criticism, simply makes possible the publication of the list of Official Nominees in CIVIL ENGINEERING, instead of in PROCEEDINGS, as is now required by the Constitution. The proposed revision affects Article VII, Section 6, second paragraph. It would strike out the words: "printed in the first number of the PROCEEDINGS issued to the membership after October 15 in each year" and substitute therefor the words: "published within thirty days after October 15 of each year."

Thirty-Seven States and Possessions Now Have Registration Laws

DURING the legislative sessions ending about June 1935, the number of states and possessions which have registration laws for professional engineers has increased to a total of 37. Those added since October of 1934 are Connecticut, Maine, Nevada, New Mexico (formerly having a law for surveyors only), Oklahoma, Utah, and Washington. In addition to the states adopting new laws, several amended their previously existing registration laws, principally to bring them more nearly in line with the now widely recognized Model Registration Law sponsored by the Society.

This increase, plus the sound purpose of making state laws more nearly uniform throughout the country, is a significant indication that engineering registration is now on a solid foundation. The legislatures of nearly all the remaining states have had some form of registration law before them for consideration during the past two or three years, adoption generally failing either because of strongly organized minority opposition, or because of apparent tactical errors or lack of organization by the proponents. It is believed that the universal adoption of registration laws is only a matter of a few years at the most. Furthermore, a practical uniformity among the laws, quite generally in line with the model law, appears now to be a reasonable expectation. There is widespread recognition that only through substantial uniformity can reciprocity in granting licenses ever be made practicable.

The list of states and possessions having registration laws, as of the end of June 1935, is as follows:

Arizona	Iowa	Oregon
Arkansas	Kansas	Pennsylvania
California (for civil engineers only)	Louisiana	Philippines
Colorado	Maine	Puerto Rico
Connecticut	Michigan	South Carolina
Florida	Minnesota	South Dakota
Hawaii	Mississippi	Tennessee
Idaho	Nevada	Utah
Illinois (for structural engineers only)	New Jersey	Virginia
Indiana	New Mexico	Washington
	New York	West Virginia
	North Carolina	Wisconsin
	Ohio	Wyoming
	Oklahoma	

Texas has a registration law for land surveyors only.

The model law was adopted in its present form by the Society's Board of Direction and eight other societies before the end of 1932, and three other organizations approved it in principle. Since the compilation of this law by a committee of authorized and unofficial representatives from 16 engineering societies, more than 3,000 copies have been distributed at the expense of the Society. The fact that no formal suggestions for changing the model law have been received, is an eloquent commentary on the sound judgment of the individual engineers who drafted it.

Copies of the model law are still available gratis through the Secretary's office for those who can make use of them.

Additional Memoirs of Deceased Members Available

CONTINUING the policy of perpetuating the technical accomplishments of its members after their work is done, the Society has made available a small supply of reprints of memoirs of 14 members who have passed away in recent months. Varying in age from 29 to 91, and in grade from honorary member to junior, these members have made many interesting contributions to the profession. Their accomplishments include such a broad variety of subjects as engineering education, early railroad construction, sanitation, structural steel building design, flood control in California, railway engineering and power development in India, highway engineering, reclamation, municipal engineering, work on the Panama Canal and the Catskill water supply of the City of New York, and military engineering in the Civil War.

The list of these 14 new memoirs is as follows:

Theron McCabe Brown	1897–1935
James Alanson Childs	1886–1935
Ernest Wilder Clarke	1868–1935
Robert Benjamin Davis	1856–1934
George Alexander Miller Elliott	1880–1934
Joseph Ingham Francis	1905–1934
Edward Louis Koch	1883–1935
Ernest Avery Lamb	1865–1935
Oscar William Melin	1888–1935
Henry Coddington Meyer	1844–1935
Sir Frederick Palmer	1862–1934
Eugene Everett Pettee	1870–1935
Palmer Chamberlaine Ricketts	1856–1935
Edward King Smith	1891–1935

River Pollution Criticized by Local Section

THAT the Cincinnati Section takes an active interest in local problems is indicated by the recent action of its Public Affairs Committee in regard to water pollution. Recognizing that the importance of the movement to stop pollution of the Ohio River warranted the approval of an informed professional body, the committee prepared a resolution which was given front-page publicity in the local press.

The resolution pointed out that the degree of pollution of public bodies of water in the vicinity of Cincinnati has created a deplorable condition, menacing health, penalizing industry and navigation, and destroying recreational facilities. It urgently recommended local, state, and national legislation and cooperation to ensure satisfactory control of pollution, and offered the support of the committee to the local officials and civic groups which are investigating means of improving conditions. Finally, it endorsed the action of the City Council of Cincinnati in initiating a proposal for a joint sanitary survey by the city and its surrounding communities.

Fall Meeting at Birmingham Offers Many Attractions

Society's First Fall Meeting Since 1932 Will Be Held October 16–19

The approaching Fall Meeting of the Society, to be held in Birmingham, Ala., October 16 to 19, will have the triple attraction of worthwhile technical contributions, interesting inspection trips and social activity. It will be the first Fall Meeting since 1932.

On the opening day, Wednesday, October 16, there will be general sessions in both morning and afternoon. Five Technical Divisions have planned programs for the following day. The Sanitary Engineering Division is arranging for papers on sewage treatment, water supply, and malaria control work. The Construction and Highway Divisions in joint session will hear discussions on low-cost road construction, construction methods at Norris Dam, and the Lake Okeechobee drainage project. Aerial and local control surveys will be high spots on the program of the Surveying and Mapping Division, and design features of bridges will occupy the attention of the Structural group.

For Friday, October 18, there has been arranged an all-day excursion to the mines, quarries, and Fairfield steel works of the Tennessee Coal, Iron and Railroad Company. Members and their guests will have the opportunity of seeing the whole operation of the manufacture of iron and steel from the raw material to the finished product. Included in the places to be inspected will

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An Aerial View of Birmingham, Ala.

be iron-ore and coal mines, limestone quarries, a by-product coke plant, blast furnaces, open-hearth furnaces, and rolling mills.

Local inspection trips on Saturday will bring the Fall Meeting to a close. Visits are scheduled to a cement plant, a cast-iron-pipe manufactory, the Shades Valley sewage treatment plant, local viaduct and underpass projects under construction, and the Mitchell and Jordan dams of the Alabama Power Company.

Traditional Southern hospitality can be relied on to provide entertainment for the ladies during the business and technical sessions of the first two days. Already on the program are an automobile drive, a tea at the Mountain View Country Club, and a luncheon bridge at the Birmingham Country Club. Events for both Members and their ladies are planned for the evenings. On Wednesday there will be a dinner, entertainment, and dance at the Thomas Jefferson Hotel, and on Thursday a buffet supper at Highland Park Country Club will open an informal party featuring cards and other entertainment.

As this will be the first meeting in the South since 1931, it should attract a large number of members who for several years have been

Blast Furnace at Birmingham, Ala.

unable to take part in Society meetings on account of the travel involved. It also offers members in other parts of the country the opportunity of a delightful fall vacation. Birmingham is a modern industrial city of more than a quarter-million inhabitants, which has rolled its way into the first ranks of the steel-producing cities of the nation and won for itself the appellation of the "Pittsburgh of the South." Yet near at hand are the quiet plantations, the regal homes, the charming atmosphere and culture of Dixie. And an easy day's journey southward carries one through cotton lands and pine woods to Mobile and the fascinating Gulf coast.

On Sunday, October 13, certain committees of the Board of Direction will meet, in advance of the Society Meeting. The Board will meet on Monday and Tuesday, October 14 and 15, and on Tuesday afternoon and evening the Local Sections Conference will be held. The Student Chapter Conference will take place on Thursday afternoon, October 17.

Certainly this Fall Meeting offers a program and a holiday that will amply repay every member for whatever effort he may have to make to attend.

Society Business Meeting to Be Held October 16

A regular business meeting of the Society will be held in the Engineering Societies Building, 33 West 39th Street, New York, N.Y., on the evening of October 16, 1935 at 8 p.m. The purpose of the meeting is to canvass ballots for amendments to the Constitution. This announcement is made in compliance with the requirement of the Constitution that corporate members shall receive official notice 15 days in advance of the meeting.

The meeting, called solely for the purpose stated, will not interfere with either the Metropolitan Section meeting or the Fall Meeting of the Society held in Birmingham on the same date.

Why Resolutions Are of Value

What is the good of a resolution? This question is sometimes asked, and the present seems to be an opportunity to make a specific demonstration in reply.

At the time of the Convention of the Society in Los Angeles on July 3, three resolutions were adopted. One endorsed the emergency expansion of the U. S. Geological Survey and the U. S. Coast and Geodetic Survey work; another endorsed the work that had been performed under the National Resources Board with respect to the country's water resources. Both these resolutions urged the continuance of these projects. The third resolution

deplored the administrative requirements which the Works Progress Administration had found it advisable to throw around the prospective expenditure of the $4,000,000,000 appropriated in the 1935 Relief Act.

It was the order of the Convention that these resolutions be sent to the President of the United States, the Secretary of the Department of the Interior, the Secretary of the Department of Commerce, and to those other administrative officers concerned. Replies have been received from the several administrative officers to whom those resolutions were transmitted and the following excerpts from their replies are worthy of note:

"Your letter of July fourth to the President has been received, and I shall bring it to his attention at the first opportunity. I can assure you that he will appreciate your interest in writing and sending him the copies of the resolutions which you enclosed.

"Very sincerely yours

LOUIS MCH. HOWE
Secretary to the President"

CONCERNING SURVEYS

"The portion of these resolutions which directly concerns this Department is that dealing with funds for continuing the work of the Coast and Geodetic Survey. This Department fully realizes the desirability of continuing these projects and is doing everything possible to secure the funds necessary to that purpose.

"Very sincerely

DANIEL C. ROPER
Secretary of Commerce"

"With regard to the question of surveys, I can inform you that there has been allotted out of Public Works funds, $350,000 to the Coast and Geodetic Survey, and $993,700 to the Geological Survey. These allotments were approved by the President on July 8, 1935.

"Sincerely yours

HAROLD L. ICKES
Administrator"

"Five applications have been submitted to the Division of Applications and Information of the National Emergency Council by the Coast and Geodetic Survey. In order that your views may be brought to the attention of the proper officials, we will attach your resolutions urging the approval of these applications to the Advisory Committee on Allotments when the allotment application is forwarded to them.

"Please be assured that the public spirit which prompted these resolutions is appreciated, and we feel confident that they will be given the utmost consideration.

"Sincerely yours

T. P. CARROLL
Special Assistant to the Executive Director

CONCERNING WATER RESOURCES

"Due to the development of new policies and a change in the funds available, it has been necessary to reorganize somewhat the work of the National Resources Committee dealing with the subject of the country's water resources. The major principles of the water resources studies, however, remain unchanged and the studies and activities will be energetically pursued by effective and experienced agencies.

"Sincerely yours

HAROLD L. ICKES
Administrator"

"I am glad to be able to assure you that the studies previously conducted by the Water Planning Committee will be continued although under somewhat different auspices. A reorganization of that work has been completed, with a new steering committee consisting of Government officials and a few outside experts

"Sincerely yours

CHARLES W. ELIOT, 2D
Executive Officer
For the Chairman"

Gustav Lindenthal, 1850–1935

GUSTAV LINDENTHAL, Hon. M. Am. Soc. C.E., died on July 31, 1935, at his home in Metuchen, N.J., following a nine months' illness. He was 85 years of age.

The works of Mr. Lindenthal were characterized by a daring inconception and execution and by a mingling of artistry with engineering technique which made him one of the outstanding bridge engineers in the country. The spanning of Hell Gate is the accomplishment with which his name is perhaps most frequently linked. At the time of its completion, in 1917, Hell Gate Bridge was the largest arch bridge in the world, and both in design features and in construction methods it marked a great forward step in American engineering practice.

It was recognized by Mr. Lindenthal that although this bridge, like all others, is utilitarian in purpose, it should be a product of art as well as of science; that something more than a thorough stress analysis—some sense of beauty and harmony and form—must have a part in the design. And to his work he was able to give such form and beauty that Hell Gate Bridge has well been said to be "one of the finest creations of engineering art of great size which this century has produced."

GUSTAV LINDENTHAL, 1850–1935
Hon. M. Am. Soc. C.E.

Mr. Lindenthal again demonstrated his artistry in steel in the design of the Chesapeake and Ohio Northern Railroad crossing at Sciotoville, Ohio—a continuous-truss structure which is esthetically something more than "just another bridge." It is important also in its engineering aspects, each of its twin spans exceeding by 300 ft the longest span of any previous bridge of similar type.

Because of a combination of circumstances, the railroad suspension bridge across the Hudson River, designed by Mr. Lindenthal in 1888 for the North River Bridge Company, was never built. It was, however, a remarkably bold and well-conceived plan, calling for the first time for a single span across the river, 2,850 ft long, and having a total length between anchorages of more than a mile. Mr. Lindenthal was still active as president and chief engineer of the North River Bridge Company until the illness which preceeded his death.

It was more than sixty years ago that Mr. Lindenthal came to this country from his native Austria. His early experience was with the Philadelphia Centennial Exposition, the Keystone Bridge Company, and various railroads. As Commissioner of Bridges for the City of New York, he completed the construction of the Williamsburg Bridge and planned the Queensboro and Manhattan bridges and the reconstruction of the old Brooklyn Bridge.

He became a member of the Society in 1882 and was elected to honorary membership in 1929. He received the Thomas Fitch Rowland Prize in 1883 for his paper entitled "Rebuilding the Monongahela Bridge at Pittsburgh, Pa.," in TRANSACTIONS, Vol. 12 (1883), page 353. Thirty-nine years later the same prize was awarded to him for his paper discussing the Sciotoville Bridge, in TRANSACTIONS, Vol. 85 (1922), page 910. In 1929 he became the first recipient of the Phebe Hobson Fowler Architectural Award.

In addition to his connection with the Society, Mr. Lindenthal was a Fellow of the American Association for the Advancement of Science; a member of the Canadian Society of Civil Engineers, the British Institution of Civil Engineers, and the Verein Deutscher Maschinen Ingenieure; and an honorary member of the Oesterreichischer Ingenieur und Architekten Verein and the Cleveland Engineers' Society.

Results of First Ballot for Official Nominees

New York, N.Y.
August 1, 1935

To the Secretary
American Society of Civil Engineers:

The tellers appointed to canvass the First Ballot for Official Nominees report as follows:

Total number of ballots received		1,553
Deduct:		
Ballots from members in arrears of dues	167	
Ballots without signature	8	
Ballots from members who have died since voting	1	
Ballots with illegible signature	2	
Total withheld from canvass		178
Ballots canvassed		1,375

For Vice-President, Zone I

Edward P. Lupfer	325
Scattering	122
Void	48
Blank	62
Total	557

For Vice-President, Zone IV

Harry W. Dennis	171
E. N. Noyes	37
Ralph J. Reed	23
B. A. Etcheverry	21
Scattering	98
Void	30
Blank	90
Total	470

For Directors, District 1 (two to be elected)

Carlton S. Proctor	188
James K. Finch	186
L. S. Stiles	157
Scattering	120
Void	72
Blank	47
*Total (385 × 2)	770

For Director, District 4

Clarence E. Myers	139
Charles Haydock	102
Scattering	6
Void	1
Total	248

For Director, District 11

Raymond A. Hill	84
Charles T. Leeds	69
Scattering	19
Void	2
Blank	5
Total	179

For Director, District 14

L. L. Hidinger	81
C. E. Boesch	9
Scattering	1
Void	9
Total	100

For Director, District 15

E. P. Arneson	57
Oscar H. Koch	54
Edward S. Bres	26
Scattering	7
Void	14
Blank	1
Total	159

Respectfully submitted,

	SHORTRIDGE HARDESTY, *Chairman*
Louis E. Robbe	A. E. Clark
H. H. Pitcairn	James F. Downey
James Wilmot	George M. Rapp
James McB. Webster	Clarence W. Dunham
John J. Cope	James A. Darling
	Tellers

* Number of valid ballots cast, on most of which were two nominations for Director.

TELLERS CANVASSING THE RECENTLY RETURNED "FIRST BALLOT" IN THE BOARD ROOM AT SOCIETY HEADQUARTERS

Regional Meeting at Zanesville Will Feature Muskingum Flood-Control Project

AT A REGIONAL MEETING of Local Sections at Zanesville, Ohio, on October 4 and 5, 1935, the Muskingum conservancy project will be the general topic of discussion. Plans for the meeting were initiated by the Cleveland Section, which has solicited the cooperation not only of all Local Sections and Student Chapters within 200 miles of Zanesville, but of the Army engineers in charge of the project as well. There has been a generous and enthusiastic response to the plans.

Construction of 14 dams and relocation of various railroads, highways, and utilities are involved in the conservancy project, which is being constructed under a cooperative arrangement between the federal government and the Muskingum Conservancy District. Saturday, October 5, will be devoted to inspection of the various features now under construction. The trail of damage left by last month's flood—the worst in 22 years—will still be partly visible to furnish mute evidence of the need for the work being done.

An interesting group of brief papers and discussions has been arranged for Friday, October 4. They include the following subjects: (morning session) history of the project, general project design, and description of project works; (afternoon session) design of dams, hydraulic model studies, railroad relocations, highway relocations, public utility relocations, control of embankment construction, and soil-mechanics application and laboratory practice. The afternoon session will be followed by an inspection of the soil mechanics laboratory, and a dinner and entertainment are planned for the evening.

The meeting is not limited to any particular territory, or to members of the Society. All interested engineers are welcome to attend. There are ample hotel accommodations, and rates for meals and rooms are reasonable.

Wills Creek Dam—Excavation and Concreting Are Getting Under Way

Clendening Dam—The Concrete Key Wall Is Visible in the Background

ENGINEERS ATTENDING THE ZANESVILLE REGIONAL MEETING WILL VISIT THIS WORK

Volume 100 of "Transactions" to Be Issued

Publication of One-Hundredth Volume in October Continues Important Engineering Record

A library of civil engineering knowledge has been gradually built up by the Society in the form of its "Transactions." Since the inception of this work in 1867, the volumes have appeared regularly through the years, and Volume 100 will be issued in October. In some years two or more volumes have been issued, and the 1905 volume contains seven bound books to accommodate the papers read at the International Engineering Congress in St. Louis in 1904. Thus, although the Society has been in existence 83 years only, there are 100 volumes which have been bound as 106 books, ending with the volume now being prepared. The separate indexes to "Transactions," which have been issued from time to time, are not included in this number. Volume 100, which includes contributions from 40 authors and 209 discussers, is an outstanding addition to the Society's reference library. Besides a considerable amount of new material, it contains such important annual features as the President's address and the memoirs of deceased members.

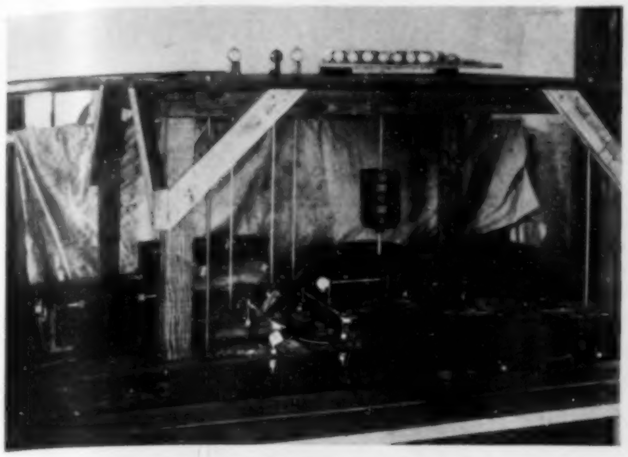
THE DEVELOPMENT OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

Each year the annual address of the President of the Society is published in TRANSACTIONS. These addresses constitute a valuable record of the current status of the Society, of the civil engineering profession, or of the country at large. They reveal the best professional thought for the time in which they were written. President Tuttle's address on "The Development of the American Society of Civil Engineers," delivered at Los Angeles, Calif., on July 3, 1935, is no exception to this rule. Excerpts from it were published in the August 1935 issue of CIVIL ENGINEERING. Those who wish to inform themselves as to the broad objectives of the Society, and its progress toward these objectives, should make it a point to read his address in full, as it will appear in Volume 100 of TRANSACTIONS.

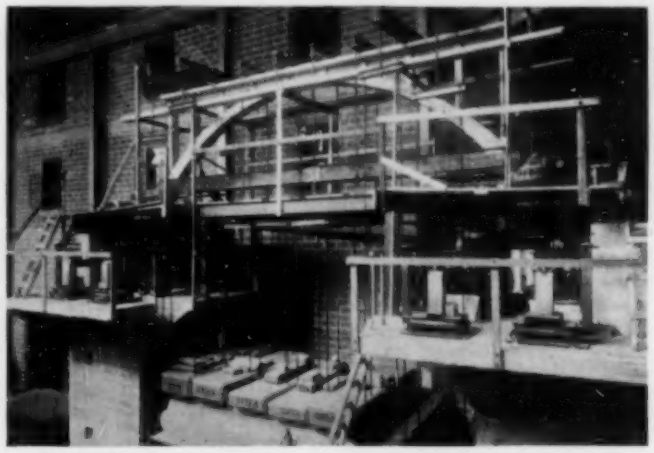
TECHNICAL MATERIAL IN VOL. 100 OF "TRANSACTIONS" NOT PREVIOUSLY PUBLISHED

Discussion by A. Streiff—A discussion of great interest, being published directly in Volume 100 of TRANSACTIONS, is that by A. Streiff, M. Am. Soc. C.E., vice-president of the Ambursen Dam Company, on the paper entitled "Security from Under-Seepage: Masonry Dams on Earth Foundations," by E. W. Lane, M. Am. Soc. C.E. Mr. Streiff emphasizes that, in the field of dams on soil foundations, experience is the best guide; that high dams now in use have lower percolation ratios than low dams; and that the Bligh ratios are now considered out of date. He claims that the factors of safety in the Lane ratios seem extravagant and offers evidence to show that they cannot be justified by the fact that escape gradients are often much greater than average. Proof is offered, furthermore, of the fallacy of the so-called flotation theory. Mr. Lane's discussion of roofing under the base slab is held to be the true key to the necessity of maintaining prevailing ratios as established by Lane's tables. Examples of security against underseepage obtained by vertical creep in dams on soil foundations are given.

Discussion by A. N. Khosla—Another contribution to the Lane paper, which arrived from India too late to be included in the May number of PROCEEDINGS, was a brief comment by Ajudhia N. Khosla, M. Am. Soc. C.E., who is executive engineer of the Khanki Division of the Punjab Irrigation District in India. Mr. Khosla draws his conclusions from a wide practical experience in this subject in his homeland.



Hard-Rubber Model of a Skew Arch
Tested Under Direction of George E. Beggs, M. Am. Soc. C.E., at Princeton University



Reinforced Concrete Model of Open-Spandrel Arch
Tested at the University of Illinois

Closure by E. W. Lane—Finally, the closing remarks by the author of this paper, E. W. Lane, M. Am. Soc. C.E., are printed directly in Transactions without first appearing in Proceedings. In the original paper, as first published in the September 1934 issue of Proceedings, considerable research information was presented, and even more material on the subject was filed for reference in the Engineering Societies Library in New York. The author's closure is a résumé of important features and a systematic answer to the problems raised in discussion.

Closure by L. F. Harza—The paper entitled "Uplift and Seepage Under Dams on Sand," by L. F. Harza, M. Am. Soc. C.E., which was first published in the September 1934 issue of Proceedings, contained among other items, a novel method of estimating the "transmission constant," *K*, in Darcy's formula. This was developed from the results of test-pit or test-well pumping in undisturbed material and interpreted by electric analogy. In his closing discussion, published for the first time in Volume 100 of Transactions, Mr. Harza once more stresses the importance and value of these findings.

Report of Special Committee on Concrete and Reinforced Concrete Arches

Only those who have been engaged in research of unusual scope can possibly have a clear picture of the work involved in producing a report of the caliber of that on "Concrete and Reinforced Concrete Arches," which is published for the first time, by the Society, in Volume 100 of Transactions.

The Special Committee on Concrete and Reinforced Concrete Arches was appointed by the late Charles F. Loweth, Past-President Am. Soc. C.E., in 1923, under an authorization by the Board of Direction. The following were selected: Clyde T. Morris (chairman), George E. Beggs, John C. Chamberlin, E. H. Harder, A. C. Janni, and Wilbur M. Wilson. Mr. Chamberlin died in 1925; but otherwise the committee has remained unchanged in the eleven exceedingly active years of its existence. To name all the research assistants and experts who have contributed many hours of thought and effort—in the laboratories of Ohio State University, the University of Illinois, Princeton University, the U. S. Bureau of Public Roads, the University of California, State of Ohio Department of Highways, the Portland Cement Association, and several others—would be a voluminous task.

Some idea of the scope of the report may be had from the following table of contents: Chapter I—Summary and Conclusions; Chapter II—Tests of Single-Span Arch Ribs; Chapter III—Tests of Single-Span Arches with Decks; Chapter IV—Tests of Three-Span Arch Ribs on Slender Piers; Chapter V—Tests of Three-Span Arches with Decks; Chapter VI—The Effects of Climatic Changes; Chapter VII—Movements of Foundations During Construction; Chapter VIII—The Effects of Time Yield on the Stresses in Arches; Chapter IX—Reaction Components for Skew-Barrel Arches; and, Chapter X—Methods of Algebraic Analysis.

Thus it will be seen that, with the exception of Chapter VIII, the report deals mainly with arches with ribs. This chapter, which concerns barrel arches, gives the results of the tests conducted at Princeton University under the direction of George E. Beggs, M. Am. Soc. C.E., which confirm the theoretical work done previously by J. Charles Rathbun, M. Am. Soc. C.E. This method of calculation may be used for concentrated loads on barrel arches whether skewed or right.

Particular attention is directed to the work on multiple-span arch systems. In the last chapter Professor Wilson presents a combined algebraic and experimental method of calculation of such systems, which is applicable to structures with or without continuous superstructures. The experimental work done at the University of Illinois under his direction is also noteworthy. The beneficial effects of plastic flow in relieving stresses in arch ribs caused by shrinkage, rib shortening, and movements of the supports are indicated by the tests described in Chapter IX, but these are not exhaustive and further study and experimentation in this field are recommended.

The finished report in Transactions will be the size of a normal number of Proceedings. Different phases of the work have been published, in meticulous detail, in various institutional bulletins, to which reference is given in the report; but a large part of it has never appeared before. Within the scope defined by the committee, the whole work is sufficiently complete, unified, and organized to serve as an encyclopedia of modern knowledge in this field.

Memoirs of Deceased Members in "Transactions"

The Society has always been interested in securing the professional records of its deceased members, the aggregate of such records being, in effect, the master memoir of the Society in relation to the profession it represents. The task of publishing memoirs is a never-ending one, and the number of voluntary contributors to this important Society activity is imposing.

A small supply of such memoirs is preprinted as soon as the manuscripts become available, and at the end of the publishing year, all of them are printed for the first time, in Transactions. Volume 100 will contain the memoirs of two Past-Presidents, one Honorary Member, 74 Members, 19 Associate Members, 3 Juniors, 1 Affiliate, and 1 Fellow.

Indexes to "Transactions"

Far from being an unorganized mass of technical data, the volumes of Transactions are so carefully indexed as to enable students in a library to reach for any of the papers (1,922 in number) published to date, regardless of the strength of the identifying clew. The aim is to publish an author index and a separate subject index in each volume and, at intervals of approximately ten years, to publish a cumulative index in a separate volume. Liberal cross-indexing, under carefully selected headings, adds to the usefulness of this service.

To explore the entire field of Transactions, requires reference to only three sources: The latest cumulative index (covering Volumes 1 to 83), published in 1920; the supplementary index (covering Volumes 84 to 99), published in 1934; and the author and subject indexes at the end of Volume 100.

The Federal Mapping Program and Unemployment Relief

A Brief Review of the Expanded Program of the U. S. Coast and Geodetic Survey

AMONG the worth-while programs for relieving unemployment during the past three years, federal mapping stands out with particular significance: First, because the results achieved are immediately usable by the public-at-large and by the various agencies of the federal government; second, because these results are not ephemeral, but constitute a national investment of untold value in future work of all kinds; and third, because a very large proportion of the money spent goes for employment.

The work of the U. S. Coast and Geodetic Survey as an aid to unemployment since the fall of 1932 is of particular interest. The expanded program began late in 1932 with a special appropriation (Wagner Bill) designed to give employment to about 1,000 men. The work was continued into 1933, 1934, and 1935 by allotments of funds made by the Public Works Administration under the provisions of the National Industrial Recovery Act of 1933. Supplemental to this program, the Survey inaugurated and conducted, at the request of the Civil Works Administration, a program of local control surveys designed to employ as many as 15,000 men. On August 1, 1935, the entire federal program was discontinued.

Beginning of Expanded Program

In the Emergency Relief and Construction Act of 1932 (Wagner Bill), which was passed by the Seventy-Second Congress and was the first emergency public works legislation for the relief of unemployment, there was included $1,250,000 for the work of the U. S. Coast and Geodetic Survey. The work undertaken through the use of this fund was carefully planned by the officers of the Survey and constituted: (1) an enlargement of the field forces; (2) the establishment of a field office in New York City for computing accumulated survey data and for making the calculations incidental to an expanded field force; and (3) expansion of the aerial mapping of coastal waters, principally along the North Atlantic seaboard.

The New York City Field Office

The New York City field office was established in November 1932, its staff being recruited largely from the ranks of unemployed engineers. On account of the limitations on expenditures, no funds were available for acquiring office space or furniture. Through the efforts of officers of the American Society of Civil Engineers and the generosity of the McGraw-Hill Company, space was furnished in the McGraw-Hill Building on West 42d Street.

Officers of the Society also secured drawing tables and desks from interested members, without charge, and the Professional Engineers' Committee on Unemployment in New York City paid for some nine months the charges for such items as heat, light, and janitor service, amounting in all to $599.02.

This office staff averaged about 30 men from its establishment in 1932 until June 30, 1933; about 50 men for the ensuing year; and increased to more than 100 in 1935. In the summer of 1933, space was obtained in the Federal Building, New York City, and the computing staff was moved there.

Also, equipment and space were secured for a small staff engaged on aerial mapping work. The space was obtained, rent free, in the McGraw-Hill Building. This force averaged some 10 men in the early part of 1932 and later was expanded to 25. The work involved the transferring of the information on aerial photographs to sheets of celluloid, which were then sent to the Washington office of the Survey and there used in making engravings and finished maps. Many of these have already been issued to the public.

Local Control Surveys

In the fall of 1933, the U. S. Coast and Geodetic Survey was required by the Federal Emergency Relief Administration to administer a project of local control surveys as a relief measure for unemployed technical men and other white-collar workers. On account of the limitations imposed on the expenditure of CWA funds, the problem of obtaining an adequate supply of suitable instruments, and of securing transportation for personnel and equipment, was a most serious one in a program that was designed to employ promptly some 15,000 men. In order to carry out the objectives, it was necessary to obtain an allotment of funds from the Public Works Administration for such expenses.

This program proceeded rapidly from the fall of 1933, when it was initiated, until early in 1934 when more than 10,300 men throughout the country were engaged on these local control surveys. The whole program was thrown into confusion by an act of Congress prohibiting participation of federal bureaus in Civil Works Administration operations. This legislation permitted the work to continue only after approval of the local projects by state Civil Works Administrations. That only four states failed to provide continuation, is evidence of the general approval of this survey program. The state representatives of the U. S. Coast and Geodetic Survey, appointed at the inception of the project, continued in charge of the work in most states, but acted only in an advisory capacity as far as the Survey was concerned. The Survey could incur no expenses in furthering the project other than pay and travel allowances of these representatives.

The Civil Works Administration went out of existence on March 31, 1934, and the work in cooperation with that agency was thereafter carried on through the Emergency Relief Administrations of the various states. Regulations regarding employment, hours of work, and so forth, designed to furnish employment only to those in the direst need, caused the almost immediate discontinuance of the local control surveys in large part throughout the country. However, at the close of 1934 some work was being done in about 23 states, employing approximately 2,900 men.

These local surveys, in general, are tied to the precise-order control surveys of the U. S. Coast and Geodetic Survey, thus bringing precise data directly into the centers of the more important communities. Great credit is due the officers and state representatives of the U. S. Coast and Geodetic Survey for overcoming the many difficulties involved in the widespread organization. Individuals, corporations, and universities, should likewise be commended for the loan or rental, on a most reasonable basis, of the necessary surveying instruments, transportation facilities, and other equipment.

Survey Programs During 1934 and 1935

During the fiscal years of 1934 and 1935, an expansion of the normal program of the U. S. Coast and Geodetic Survey has been carried on under allotments of Public Works funds. Some 2,300 or 2,400 men, largely recruited from the ranks of the unemployed, have normally been employed in this expanded work. About 60 per cent have college training. In this program about 1,250 men, under the direction of Coast Survey officers, were engaged on control surveys which, when completed, will form a network of permanent monuments whose geographic coordinates and elevation have been accurately determined. This network will have a 25-mile spacing, which means that no point in the country will be farther than $12^1/_2$ miles from an established point of reference of high accuracy. Approximately 1,000 men were engaged on hydrographic surveys charting the coastal waters of the Atlantic and Pacific oceans and Alaska. A small number of men were also engaged in making tidal surveys and magnetic observations.

Plans for continuation of the work had been made and allocation of funds had been requested from the $4,800,000,000 Emergency Relief Appropriation Act of 1935. At the close of the fiscal year, June 30, 1935, approval of the allocation had not been received but assurances seemed so promising for continuation that a loan of $350,000 for carrying on the work during the month of July was obtained from the Public Works Administration.

The application for funds to continue the mapping program did not comply with the rigid rules and regulations regarding manning of the project from relief rolls and had to be recalled for revision. In the meantime, the exhaustion of available funds, at the close of July, forced the Coast and Geodetic Survey to discharge 2,400 men employed on the work in various parts of the country. As of the middle of August 1935, interested engineering organizations and the U. S. Coast and Geodetic Survey are endeavoring to develop a project that will comply with the work relief employment regulations, and to obtain funds to reorganize the parties at the earliest possible date.

Activities of Local Sections Increase

For the past few years, during the period of economic maladjustment that has put so many engineers out of work, the Society's main objective has been to find employment for its members. These efforts necessarily consumed much time and energy, leaving the Secretary and other Society officers little opportunity to make their usual visits to Local Sections and to keep in touch with members in these groups. However, in the past year conditions have changed to such an extent that already officers and representatives from Headquarters have been able to make contact with nearly every one of the 57 Local Sections.

Even members outside the United States have not been overlooked. In March Mr. Richmond, Assistant to the Secretary, paid a visit to the active Puerto Rico Section. On his return from the Los Angeles Convention in July, Secretary Seabury visited with members of the Society in Guatemala and San Salvador, members of the Panama Section residing at both ends of the Canal Zone, and still other members in Havana. A high degree of interest in the Society's work was shown in all these places.

Continuing his circuit among the Sections in the United States, Field Secretary Jessup returned from the Los Angeles Convention by a route that included the Arizona Section in Phoenix; the San Diego, Los Angeles, San Francisco, and Sacramento Sections in California; the Portland Section in Oregon; the Tacoma, Seattle, and Spokane Sections in Washington; the Northwestern (Twin Cities) and Duluth Sections in Minnesota; and the Illinois Section in Chicago. It is planned that when the universities open this fall he will continue his activities in the field and will meet with the Local Sections and Student Chapters that he has not yet had the opportunity to visit.

Since early last fall, the Society's Committee on Aims and Activities has been studying the formulation of a program of Society activity that would be of greatest benefit to the Society and its membership. One of its important conclusions was a unanimous decision that the problems of the Local Sections should receive first consideration. The carrying out of this program now falls to the newly appointed continuing committee authorized by the Board of Direction at its Los Angeles meeting. The new Committee on Aims and Activities is "to initiate, to energize, and to develop Society policies looking toward the betterment of the professional and economic status of the membership." Since March the Field Secretary has been assisting the committee by discussing Society activities with groups in Local Sections, by obtaining suggestions for the direction of Society and Local Section effort into new channels, and by unearthing every bit of constructive criticism of the Society's current activities that is obtainable.

A member of one Local Section was disturbed about these visits of the Field Secretary, fearing that the Society was about to engage in a membership campaign. He was very much relieved to learn that never before have the assets of the Society been greater, and that applications for admission are greatly increased above those of the earlier years of the depression. He was pleased to hear that these visits were for the purpose of finding additional ways in which the Society could be of service to its members.

In this connection an officer of another Section said that for 83 years the Society has performed a creditable technical service to the profession as an engineering society, but that about 15 years ago it began to consider the engineer as an individual as well. Now it is expending a still greater proportion of its effort in caring for the economic welfare of the individual member.

With the hope that each Local Section will become a real instrument of the Society, President Tuttle made a recommendation in his annual address at the Los Angeles Convention that every member of the Society be assigned to a Local Section, and that there should be at least one Local Section in each state. He further recommended that because of the responsibilities of a Section's secretary, he should be a paid officer. At the present time, President Tuttle pointed out, less than half the membership (6,254 members) are affiliated with Sections. The remainder get the Society's publications and other intangible benefits but do not obtain the advantages of personal relationships available through Local Sections.

These and many other suggestions for increasing the Society's service to the profession, and the usefulness of its Local Sections to its members, are to be considered by delegates from 14 Local Sections in the southern meeting region when they convene at a conference in Birmingham, Ala., on the afternoon and evening of Tuesday, October 15, 1935, during the Fall Meeting of the Society. Those to be represented are the Alabama, District of Columbia, Florida, Georgia, Louisiana, Maryland, Miami, Mid-South, North Carolina, Oklahoma, South Carolina, Tennessee Valley, Texas, and Virginia Sections. Arrangements are going forward to acquaint the Sections concerned and their delegates with the details of the agenda for the conference.

American Engineering Council

The Washington Embassy for Engineers, the National Representative of More Than 200 National, State, and Local Engineering Societies Located in 40 States

Construction and Employment Notes

Numerous projects under the work relief program have been approved during the past month. Now that allocations of funds have been made to operating units and the general organization of the program has taken form, the program is developing toward a peak in field operations scheduled for about November. Most of the agencies entering the work relief field have outlined their procedure fairly well. Much of the apparent delay is now developing into what seems to be better planning, which utilizes experience gained in recent years and should tend to eliminate waste and confusion.

The Works Progress Administration is looking ahead to next winter and is seeking carry-over projects for the employees displaced from its construction work by weather conditions. The purpose is to provide continuous work for all relief employees.

Another interesting development is the introduction of the Reconstruction Finance Corporation into the rural electrification program by way of a reorganized Electric Home and Farm Authority, which will loan RFC funds to farmers for electrification of their homes, farms, and cooperative enterprises.

Applications for new non-federal projects are being received by the Public Works Administration under the new plan of 45 per cent federal grant and 55 per cent loan, revised from the 30 per cent grant and 70 per cent loan formerly in effect. After a project has been approved, 15 per cent of its cost may be made available for plans and surveys. The interest rate is back at 4 per cent.

The Federal Housing Administration has raised its limitation on modernization credit from $2,000 to $50,000. This includes jobs large enough to employ engineers. Regulations have been liberalized as to purchase of machinery and equipment.

Region No. 1 of the Federal Housing Administration, which formerly covered only the State of New York, has been extended to include Connecticut and Rhode Island. Julian M. Gerard has been appointed director of the region and Thomas G. Grace, director for the State of New York. Both make their headquarters in New York City.

The National Youth Administration, newly organized as reported in the last letter, has announced that its aid to high school and college students from relief families will take the form of part-time work.

Special surveys planned by the Bureau of the Census may be of interest, especially to engineers not physically able to do field work. A census of business during 1935, covering all fields except manufacturing and agriculture; a national survey of retail trade; and an alphabetical index of all individuals included in the Census of 1900 are among the projects recommended.

Other News Items

A dinner meeting in honor of John Monroe Johnson, newly appointed Assistant Secretary of Commerce, was held in Washington on the evening of July 30 at the invitation of J. F. Coleman, President of the Council. Mr. Johnson is a member of the American Society of Civil Engineers and since 1898 has been in engineering practice at Marion, S.C. Executive engineers from WPA, PWA, RA, REA, and other federal agencies met with President Colemen and the Council's staff at a luncheon on July 30.

E. B. Meyer, new president of the American Institute of Electrical Engineers and chief engineer of the Public Service Electric

and Gas Company, of Newark, N.J., will represent the A.I.E.E. on the Assembly of the Council for the coming year (12 months).

A program for accrediting engineering schools in New England and the Middle Atlantic States has been announced by the Engineers' Council for Professional Development. After a trial period in these regions, the program will be offered to the other parts of the country. Regional subcommittees have been set up to visit each institution requesting recognition.

A semi-monthly news service will be offered by the Engineering Council to member societies only, starting concurrently with this issue of the monthly News Letter, which will be continued for general release. The supplement previously issued with the monthly letter for state and local societies will be discontinued. Its field is among the phases to be covered by the semi-monthly service, which is intended to aid the state and local societies with their public affairs, public relations, and allied work.

The Student Loan Fund Administration Committee of the Grand Rapids Engineers' Club is giving financial aid to two worthy engineering students in their last year—one at the University of Michigan and the other at the Michigan College of Mines. This is an activity that well deserves emulation by other societies.

Washington, D.C.
August 15, 1935

Juniors of the Metropolitan Section Plan Active Year

By ALFRED HEDEFINE, JUN. AM SOC. C.E.
WITH WADDELL AND HARDESTY, NEW YORK, N.Y.

THIS FALL marks the beginning of the fifth year for the Junior Branch of the Metropolitan Section of the Society. The Juniors were organized under the sponsorship of that Section in the spring of 1932, for the purpose of encouraging fellowship and closer contact among Junior engineers; providing training and practice in effective speaking; and affording an agency through which the Juniors can work with and serve the Section and the Society more effectively. Through the activities of this organization, real progress has been and is being made in improving materially the present status and future opportunities of the Juniors. The formation and advancement of the Junior Branch have been largely due to the wholehearted efforts of the Committee on Juniors of the Metropolitan Section, which has thus initiated a movement worth consideration by other Sections.

During the past year a course in effective public speaking was given to the Juniors under the direction of Alexander Haring, M. Am. Soc. C.E. This course has proved valuable in developing the ability of the participants in the art of self-expression. A member of the Junior Branch serves on each of the standing committees of the Metropolitan Section, and through reports made by these members the Juniors have been given a better understanding of the Society work of the older members. The program that has been outlined by the Juniors for the coming year contains features that are both interesting and educational, including addresses by a number of prominent speakers.

At their first meeting this fall, September 24, D. B. Steinman, M. Am. Soc. C.E., consulting engineer, will address the Juniors on the subject, "Engineers' Registration and Related Problems of the Profession." There is no doubt that Dr. Steinman will have a great many things to say of importance to Juniors as future professional engineers.

Ben Moreell, M. Am. Soc. C.E., an authority on concrete structures in this country, also spent considerable time among engineering circles in Europe. In March he will speak to the Junior group on the topic, "Comments on French Engineering, Training, and Practice," affording an excellent opportunity for the Junior group to learn about professional practices abroad.

On February 11, George T. Seabury, Secretary of the Society, will explain in detail the structure, workings, and functions of the Society. There is no better authority on this subject than Mr. Seabury, whose address on the real significance of the Society will mean a great deal to all Juniors. It has always been considered one of the foremost aims of the Junior group to secure practice and instruction in effective speaking, and the majority of the coming year's meetings have been planned with this purpose in mind. The Juniors themselves will take an active part by giving short talks, reports, slide lectures, and discussions on both technical and civic subjects. The sessions will be conducted under a system of rotating chairmen, which provides a new chairman for each meeting. It is planned to hold an annual speaking contest in the spring with prizes for the winners. This contest takes place at a regular meeting of the Metropolitan Section. Tentative plans are being made for a number of Saturday inspection trips to local construction projects of unusual engineering interest. Arrangements have also been made for several social gatherings in the form of dinner meetings.

Meetings are held at 7:30 on the second and fourth Tuesdays of each month, on the fifteenth floor at Society Headquarters, 33 West 39th Street, New York, N.Y. All Juniors residing in the Metropolitan District are eligible to attend and participate. Any Junior engineers from other parts of the country visiting the New York metropolitan area are cordially invited to attend the meetings. The officers of the Junior Branch for 1935 are Alfred Hedefine, president; George L. Curtis, first vice-president; Harold S. Farney, second vice-president; Lt. Daniel Hunter, treasurer; and Orrin H. Pilkey, secretary, Room 1608, 33 West 42d Street, New York, N.Y.

Student Chapters to Hold Conference at Time of Birmingham Meeting

WITH the resumption of fall meetings of the Society, beginning with the meeting at Birmingham in October, it has become possible to revive the Student Chapter conferences of former years. The Board of Direction has approved the recommendation of the Committee on Student Chapters that a conference be held at Birmingham on the afternoon of Thursday, October 17. It is expected that representatives and members from all Student Chapters within a radius of three or four hundred miles will attend.

This conference will be the students' own affair. Each Chapter will be asked to send a spokesman, but the success of the gathering will be measured largely by how many members of each Chapter get to Birmingham. Most conferences have been attended by from 50 to 100 student members, with a record student registration at St. Louis in 1930 of more than 200. The last conference of this type was held at Atlantic City, N.J., in October 1932.

A large number of students from the vicinity should be attracted by the opportunity of combining attendance at a student conference with a fall inspection trip such as is usually conducted by engineering schools. Elsewhere in this issue the trips which have been arranged in connection with the Fall Meeting are described. As all student members are cordially invited to participate in them, faculty advisers should have no difficulty in arranging for a rather complete migration of their Chapters to the Birmingham Meeting.

Detailed letters of information will be sent to all nearby Chapters, but it should be clearly understood that any student from any part of the country who can arrange to come to the meeting will find a cordial welcome and an opportunity to take part in the conference, the inspection trips, and other functions of the Fall Meeting.

Society Appointees

F. W. GREEN and J. L. VAN ORNUM, Members Am. Soc. C.E., will represent the Society at the winter meeting of the American Society for the Advancement of Science, to be held in St. Louis, Mo., December 30, 1935, to January 4, 1936.

GEORGE L. LUCAS, M. Am. Soc. C.E., will represent the Society on the Division of Engineering and Industrial Research of the National Research Council.

ROBERT RIDGWAY, Past-President Am. Soc. C.E., and J. W. ALVORD and T. L. CONDRON, Members Am. Soc. C.E., have been appointed a committee to write the memoir of the late CHARLES F. LOWETH, Past-President Am. Soc. C.E.

ARTHUR S. TUTTLE, President Am. Soc. C.E., will serve as a Society representative on the John Fritz Medal Board of Award for the four-year term beginning October 1935.

Preview of Proceedings

By Harold T. Larsen, *Editor*

At least three papers will be offered to the membership for discussion in the September issue of "Proceedings." The subjects vary from Venturi flumes, through erosion control, structural design, and hydraulics in tunnel and penstock flow, to photo-elasticity. If space is available, it is hoped that two other papers may be included in the September issue. In any event, these two papers will be published in the October issue of "Proceedings," and their appearance will be awaited with interest by a large proportion of our membership.

Adaptation of Venturi Flumes to Flow Measurements in Conduits

Having experienced considerable difficulty in measuring, accurately, the flow at various points in a large system of sanitary sewers, H. K. Palmer, M. Am. Soc. C.E., and F. D. Bowlus, Assoc. M. Am. Soc. C.E., designed and tested a number of Venturi flumes, adapted to give more accurate results. They have developed a method of installing these flumes in a conduit of any shape, so that the flow may be determined by a single depth measurement taken in the conduit above the throat. In a paper on "Adaptation of Venturi Flumes to Flow Measurements in Conduits," scheduled for the September issue of Proceedings, they report a series of tests on these devices. Although the flumes have been successfully installed and operated in sewers already constructed, they may also be used in irrigation canals, storm drains, and other open channels, the only requirement being that the conduit have a fairly uniform cross section.

Recognizing the fact that the final measurements must be made with a stage recorder which has only a limited accuracy, no attempt is made to develop an empirical formula, but a rating curve for each installation is drawn from formulas depending on basic hydraulic principles. The stream-lined throat, which may be of any shape best suited to the hydraulic constants of the conduit, is so designed that water will flow through it at critical velocity.

Flood and Erosion Control Problems and Their Solution

Modern development, necessarily, upsets nature's physical balance. Protective measures must be taken to offset hazards thus created. Roads on mountains and foothills will collect innumerable small flows, which will be concentrated in certain locations. Fires destroy vegetative cover and enormously increase erosion rates, particularly on the steeper slopes.

On the valley floor, buildings and roads reduce the amount of percolation into subsurface reservoirs, and increase rates and amounts of runoff. Developments crowd and constrict river channels where, formerly, ponding occurred over large areas and slower draining was permissible.

Such resulting problems and their recommended solution are described in a forthcoming paper by E. Courtland Eaton, M. Am. Soc. C.E. Physical conditions of Los Angeles County, California, are described; and historic floods are given, together with the estimated expectancy of flows under conditions of recurring precipitation similar to those producing previous floods.

The subject is treated under the heads of flood and debris flows. The former covers expected flood quantities on the larger mountain watersheds, and the latter the debris flows recorded from smaller foothill watersheds where the vegetation had been previously denuded by fires.

Methods of computing flood flows are given in a résumé of details of hydraulic studies on the Big Tujunga watershed (124.5 sq miles), where a maximum possible flood, occurring in four successive days, was estimated at 72,462 acre-ft. This resulted from a 30.3-in. rainfall, or a ratio of runoff to rainfall of 36 per cent. The required regulating storage was estimated, in this instance, at 32,500 acre-ft, or 260 acre-ft per square mile of watershed.

Records of fires, from 1919 to 1934, are mapped and tabulated, and tribute is paid to the excellent results attained by federal, state, and county forestry agencies in preventing greater conflagrations. The importance of taking the fullest possible fire-prevention measures is stressed.

The paper gives measured quantities of debris flow from four areas, including measurements from the La Crescenta-Montrose territory, made on January 1, 1934, amounting to more than 90,000 yd per square mile during a single storm. The use of debris basins as a protective method is discussed. The paper concludes by citing measurements of rates of stream-bed percolation into subsurface reservoirs, showing how conservation of flood wastes will result from reduction in peak flows and regulation for flood protection.

The Relation of Analysis to Structural Design

A paper by Hardy Cross, M. Am. Soc. C.E., entitled "The Relation of Analysis to Structural Design," was read before the Structural Division of the Society on January 17, 1935. It was abstracted very lightly for publication in the April 1935 issue of Civil Engineering and, because of the wide interest it created at that time, it is now being published in full in the September Proceedings, so that all who have ideas on this subject may discuss it at will. Professor Cross emphasizes the futility of analyses that are not carefully interpreted in terms of design and suggests a basis for such interpretation. He presents a classification containing four types of structural action: (1) deformation stresses; (2) "participation" stresses; (3) normal structural action; and (4) hybrid structural action. The complete paper contains only about 12 pages but these are packed with common sense.

The Airy Stress Function and Photo-Elasticity Applied to Dams

A forthcoming paper on "The Airy Stress Function and Photo-Elasticity Applied to Dams," by J. H. A. Brahtz, Esq., had its beginnings in a study of the Pine Canyon Dam at the California In-

Snover Canyon Watershed
Burned in November 1933

Boulder Weighing $59^1/_2$ Tons Washed Into Highway
At the Mouth of the Dunsmuir Canyon on January 1, 1934

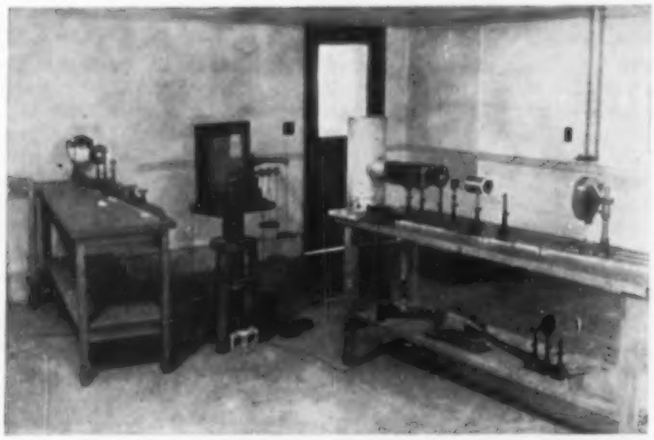


Photo-Elastic Laboratory at the California Institute of Technology

stitute of Technology, where the theory and the experiments were also developed. Subsequently, the work was further augmented by studies of the Grand Coulee Dam. Experimental research on the problem of stress distribution in gravity dams has probably never before been treated as thoroughly as in the present case. The experiments demonstrate the limits to which the present methods of computation are valid and may suggest, in the light of discussion, some essential improvement over present methods to engineers who are interested in the question. One interesting phase of the paper is that it emphasizes the undesirability of sharp corners at the heel or toe of concrete dams, and it adds another link in the growing mass of testimony as to the value of model tests in connection with the design of high dams.

The paper is divided logically into two papers, Part I pertaining to the theory and the development of the Airy stress function, and Part II discussing photo-elastic experiments in connection with Morris Dam in California.

Tunnel and Penstock Tests at Chelan Station, Washington

A paper entitled "Tunnel and Penstock Tests at Chelan Station, Washington," by Ellery R. Fosdick, Esq., is ready for publication in the September Proceedings, space permitting. Chelan Lake has been formed by a glacial-fill across the lower end of the former Chelan Gorge. Its outlet, the Chelan River, flows through what now remains of the Chelan Gorge for a distance of about 2 $^1/_3$ miles of the Columbia River. The storage reservoir formed by the Lake is the source of power for the Chelan hydro-electric development. The penstock required for connecting the reservoir and the power house is an unusually long one. Mr. Fosdick makes available a thorough and detailed analysis of flow-line losses in this penstock. For example, the paper includes a discussion of: (1) the losses that occur in each part of the flow-line; (2) the coefficients of roughness that are applicable to the large concrete and steel lined pipes in these installations; (3) an unusual and complete analysis of the losses that occurred in a large wye branch; and (4) a segregation of "diversion" losses in the wye branch and the lower penstock bends from losses due to frictional resistance. The latter study furnished a means of checking the laboratory tests and research work that were being conducted along this line.

News of Local Sections

Duluth Section

At a luncheon meeting held on July 15 the members of the Duluth Section heard a talk given by Franklin Rice, electrical engineer of the Minnesota Power and Light Company, who described the damage to their power system caused by a recent sleet storm. On August 5 a special dinner meeting was held in honor of Walter E. Jessup, Field Secretary of the Society, who led an interesting discussion on the problems of the Society. There were 22 present at this session. On the following day Mr. Jessup was the guest of the Section on a trip to the Mesabi iron mining range.

Georgia Section

There were 42 present at a luncheon meeting of the Georgia Section held on August 12. The first speaker was J. Houstoun Johnston, state engineer of the Georgia State Advisory Board for the PWA, who outlined briefly methods of handling the various PWA projects. Then W. A. Hansell, of Atlanta, spoke on the city bond issue for the sewer system of Atlanta. An animated discussion of the "occupation tax" on engineers occupied the rest of the session.

Illinois Section

The Illinois Section of the Society recently issued its 1935 year book. This 40-page booklet lists the names and addresses of the 289 members of the Section; former officers of the Section; the prize-winning students in the annual contests for the award of junior membership in the Society; and the present officers and local committee personnel. The constitution of the Section is included, and there is a chronological list of membership statistics since 1916, when the Section was organized. A slight increase in the 1934 membership over that for 1933 indicates that the low point of the depression has apparently been passed.

Kansas City

On June 24 a luncheon meeting of the Kansas City Section was held, with 39 members and guests in attendance. The guest of honor was George T. Seabury, Secretary of the Society, who discussed the recent activities of the Society, emphasizing particularly the welfare work that it has done and is expected to do in co-operating with the federal administration. A general discussion followed on the subject of the local situation, and in conclusion Clark E. Jacoby, of the Clark E. Jacoby Engineering Company, outlined the qualifications that he will require in hiring men.

Northwestern Section

The Northwestern Section recently held a special meeting in St. Paul, Minn., for the purpose of hearing Field Secretary Jessup and James L. Ferebee, Director. The program was given over to a discussion of Society affairs, both local and national.

Portland (Ore.) Section

On July 25 a special meeting of the Portland (Ore.) Section was called, the occasion being a visit from Field Secretary Jessup. There were 13 members of the Section present, in addition to L. B. Reynolds, former president of the San Francisco Section, and A. T. Cushing, a member of the Kansas City Section. Various business matters were discussed, after which Mr. Jessup gave a talk on Society affairs. An enthusiastic discussion of his remarks followed from the floor.

Puerto Rico Section

Various business matters were discussed at a meeting of the Puerto Rico Section held on June 15, particular consideration being given to recent action of the Board of Direction. Then Clar de Margarit, a Spanish engineer, delivered a lecture on the subject, "The Defense of a Naval Base," in which such a base at the northeast corner of Puerto Rico was discussed. It was stated at this session that the Puerto Rico Relief Administration, at the request of the Puerto Rico Section and the Sociedad de Ingenieros de Puerto Rico, has increased the salaries of its engineers, the minimum wage now being $125 a month.

San Diego Section

A special meeting of the San Diego Section was held on July 16 in the U. S. Grant Hotel to enable the members to meet Walter E. Jessup, Field Secretary of the Society. In a brief talk Mr. Jessup described his duties as Field Secretary, gave a résumé of recent Society activities, and described the functioning of the office at Society Headquarters in New York. In the general discussion that followed the members asked many questions about Society activities.

Virginia Section

W. D. Tyler, vice-president of the Clinchfield Coal Corporation at Dante, Va., has been appointed president of the Virginia Section to fill the unexpired term left vacant by the death of R. Keith Compton.

ITEMS OF INTEREST

Engineering Events in Brief

Civil Engineering for October

Among the interesting articles scheduled for the October issue is one on the "Improvement of the Lower Huangho," by Ludwig Brandl, advisory engineer to the Yangtse River Commission, Nanking, China. The Huangho or Yellow River, approximately 2,500 miles in length, is the source of many of the floods which from time to time devastate the north China plain, and which have earned it the name of "China's Sorrow." The great flood of 1933 overran more than 4,500 sq miles and devastated more than 9,000 villages. In its lower reaches the river in the course of centuries has deposited silt or loess to such an extent that its surface is at many points from 15 to 20 ft above the adjacent plain. Mr. Brandl tells how the repair of the dikes at various points has been effected by the use of willow trees, either floating or weighted down with mud bricks. The water-borne silt quickly collects in these obstructions, which thus act to confine the stream. Constant dike patroling and repair is the price of safety from floods, Mr. Brandl believes. The erection of storage reservoirs on the river and on such larger tributaries as the Weiho, and the construction of an irrigation ditch drainage system for storing rain water are recommended as ultimate goals.

The Mississippi River presents a somewhat similar flood problem at points much nearer home, as outlined by Lytle Brown, M. Am. Soc. C.E., Brigadier General, U. S. Army, and former Chief, U. S. Engineer Corps, in his article "Waterway Improvements in the United States." The present plan for flood control on this stream contemplates the building of higher levees; and, for times of extraordinary flood, the provision of openings in the levee system to allow the flood waters to escape to the sea by other routes. A third possibility is the building of storage reservoirs, but the cost of this would be staggering. General Brown estimates that a reservoir adequate only to take care of the water that it is proposed to divert from the lower Mississippi would cost in the neighborhood of $2,000,000,000. The paper also discusses improvements to Mississippi tributaries and to other streams, and details some of the work done by the U. S. Engineer Corps in deepening and maintaining harbor channels and in providing anchorages at various points along the coast.

In an article on the new importance of city planning, Harland Bartholomew, M. Am. Soc. C.E., city planning consultant of St. Louis, Mo., points out the municipal extravagance and waste of allowing unregulated growth of suburban districts while large central areas are permitted to decay, depreciating in value beyond the point where they can bring enough return to pay the taxes. Mr. Bartholomew believes that the average American city is unsound today, but that the official adoption of comprehensive city, county, and regional plans will bring back a stable condition. Zoning, reconstruction of slum areas, neighborhood rehabilitation, and provision of low-cost housing are among the more important points in such a planning program.

Vertical-lift bridges as a rule are no novelty to engineers, but the temporary timber lift span used to handle railway traffic during the construction of the Tower Bridge project at Sacramento, Calif., has many unusual features. This span is discussed, in the October issue, by H. J. Whitlock, Assoc. M. Am. Soc. C.E., associate designing engineer for the Division of Highways of the California Department of Public Works. The Division of Highways was faced with the problem of providing for considerable railway and boat traffic while complying with War Department requirements for a clear channel 80 ft wide with 85-ft vertical clearance above high water. The Division was also under the necessity of constructing the temporary bridge in such a position that the base of rail would be only 20 in. above high water. Consideration was also given to speed of construction, elimination of falsework, and possible salvage value. Under these conditions, a span of the vertical-lift type was adopted. The towers were constructed of timber on wood pile bents and were adequately braced against wind and train loads. The use of timber connectors simplified the erection of the towers and increased their strength and stiffness. The lift span was not fully counterweighted but was raised by hoisting the unbalanced load and lowered by gravity under control. The operating machine and control are unusual and interesting.

Practical Tribute Recalled by Death of Oscar Stout

The recent death of Oscar Van Pelt Stout, M. Am. Soc. C.E., recalls an interesting incident in connection with his admission to the Society. He had been professor of engineering and later dean of the Engineering School at the University of Nebraska for a great many years, and had won the respect and affection of a large number of young men who had received their engineering training under him. Among them was former Director J. C. Stevens, M. Am. Soc. C.E.

In 1926 Mr. Stevens conceived the idea of presenting Dean Stout with a tribute from his former students. "I wrote to a large number," said Mr. Stevens recently, "and got back some 160 letters—mementoes of their regard for him—together with a small check for a gift. They were all sent to me and I had them bound into a volume with a suitable inscription."

It was suggested to Mr. Stout, who was not at that time connected with the Society, that he make application for membership. A part of the money which had been collected was then sent secretly to the Secretary to pay his initiation fee and first year's dues and purchase a badge and certificate of membership.

When Mr. Stout was accorded membership a few months later, notification was withheld until a "party" was arranged by the San Francisco Local Section. There, in the presence of Mrs. Stout and some 200 members and guests, Mr. Stout was informed of his election and was presented with the letter so advising him, the badge, and the certificate. He was also handed a bank book showing a deposit which, with interest, was sufficient to pay his dues for 10 years. The part unused at the time of his death has recently been turned over to Mrs. Stout.

Helping Young People to Choose a Vocation

A permanent occupational exhibit, taking the form of stages, scenes, pictures, short descriptions, and possibly a diorama, is being designed by the Board of Education of New York City. The work of analyzing the professions and other occupations and laying basic plans for the exhibit has been in progress for several months under a project now financed by the Works Progress Administration, employing a group of educational experts. The purpose of this project is to show school children, graphically, what people do in pursuing each of a considerable number of the better-known occupations, or in other words "to create an occupational exhibit showing opportunities and requirements in various occupational fields with a view to helping young men and women in secondary and continuation schools choose courses of study."

Some of these callings can be shown quite simply, while others, particularly professions, require highly technical advice to insure clear and accurate delineations. The staff at Society Headquarters has been assisting the occupational exhibit to initiate its analysis of the engineering field. However, since the project applies to the New York City school system only, the bulk of the advisory work will be done by the Metropolitan Section's Committee on Vocational Guidance, headed by Chairman Arthur G. Hayden, M. Am. Soc. C.E.

Roughly, the plan contemplates a series of stands or cabinets, each supporting a picture, stage scene, or diorama of the environment within which some particular occupation is carried on. A title and

a brief description of what each worker in the picture does will appear, and it will also be explained what qualifications, particularly as to education, are required for him. For example, an engineering unit might show a large scene of a dam, reservoir, power house, and transmission line under construction. On the dam there would appear the figures of a construction engineer and a superintendent scanning the blueprints for the job. The legend would indicate that the construction engineer supervises the work, sees that the job is done in accordance with the plans and specifications, and devises means by which the structure can be safely and economically erected in accordance with the plans. It would state that he is almost always a graduate of an engineering course requiring at least four years.

In one corner would be shown a building in which a designing engineer could be seen at work on plans. A suitable legend would explain his part in the project. On the shore of the reservoir there might be a surveyor, and in the power house mechanical and electrical engineers might be seen supervising the installation of turbines and generators. Appropriate legends would explain their work.

Water Planning Will Continue as Urged by Society

FEARING that the water-planning work of the National Resources Board might be laid on the shelf by the National Resources Committee when it succeeded that board, the Society, at its Los Angeles Convention early in July, prepared a resolution urging that the new organization set up a distinct agency to continue the preparation of a long-range plan for development and control of water resources. It is gratifying that such an agency has now been set up. It is called the Water Resources Committee, and consists of representatives from government agencies dealing with water problems, plus four other experts in that field.

This committee has been engaged since July 30 in outlining a long-range plan for the more effective use of all the water resources of the nation and for continuance and application of the policies set forth in the report of the Mississippi Valley Committee and the December 1934 Report of the National Resources Board.

Of the eleven appointees to this committee, the following are members of the Society: Abel Wolman, chairman, also chairman of the Maryland State Planning Board; Thorndike Saville, Associate Dean of the College of Engineering, New York University; N. C. Grover, Chief Hydraulic Engineer, Water Resources Branch of the U. S. Geological Survey; Elwood Mead, Director of the Bureau of Reclamation; Maj. Gen. Edward M. Markham, Chief of Army Engineers; and Edward Hyatt, State Engineer of California. The remaining committee members are Jay N. Darling, Chief of the Biological Survey; H. H. Bennett, Chief of the Soil Conservation Service; R. E. Tarbett, Sanitary Engineer of the Public Health Service; Thomas R. Tate, Director of the National Power Survey of the Federal Power Commission; and H. H. Barrows, of the University of Chicago, formerly a member of the Mississippi Valley Committee and the Water Planning Committee of the National Resources Board.

The former Water Planning Committee and the consultants working with the National Resources Board have been retained in an advisory capacity for the work of the new committee. Brent S. Drane, M. Am. Soc. C.E., has been appointed secretary of the new committee, and will serve with Gilbert C. White, M. Am. Soc. C.E., on the regular staff of the National Resources Committee under its executive officer, Charles W. Eliot, 2d.

Government Announces Openings for Junior Engineers

THE U. S. Civil Service Commission, Washington, D.C., announces that applications for the position of junior engineer must be on file with that office not later than September 16, 1935. Optional subjects are aeronautical, agricultural, ceramics, chemical, civil, electrical, mechanical, mining, petroleum, and structural steel and concrete.

The entrance salary is $2,000 a year, less a deduction of $3^1/_2$ per cent toward a retirement annuity. Applicants must have been graduated with a bachelor's degree in engineering from a college or university of recognized standing on completion of a full four-year course.

Bonneville Design Problems Simplified by Models

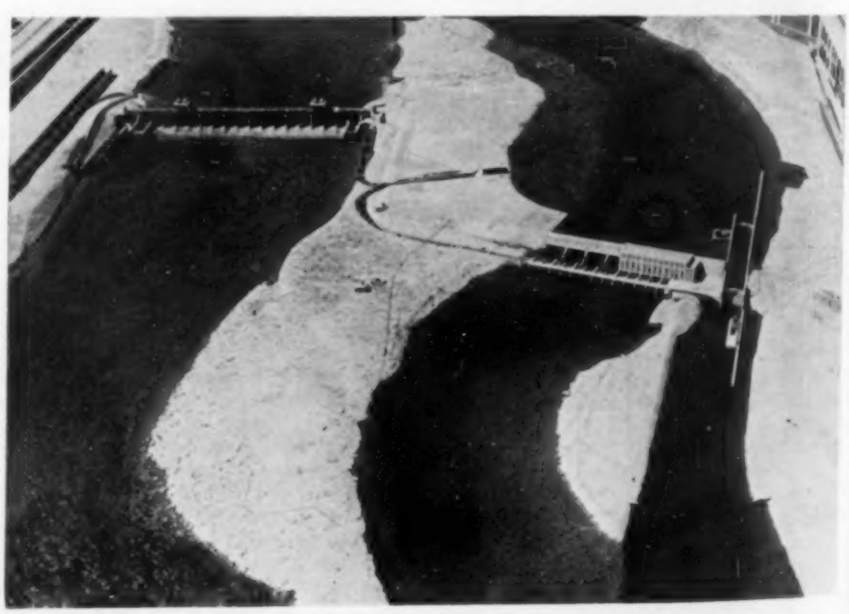
TO AID IN the design of the Bonneville Dam and to verify the hydraulic calculations for it, two hydraulic models have been built at Linnton, Ore. The one shown in the illustration is used for studying cofferdam construction, scour and silting below the dam, navigation problems, backwater effects, and the handling of fish; the other—called the spillway model—is used to determine the most desirable shape for piers, crest, toe, and apron of the spillway dam.

Accurate to the last detail, the river model reproduces, on a scale of 1 to 100, some five miles of channel and banks. Parts of the model are composed of blocks which can be taken out at will to study the effect of channel improvements. The spillway dam, power house, and lock are also removable. Provision was made for a movable bed for certain experiments.

The spillway model reproduces three bays of the spillway dam on a scale of 1 to 36. It is made in many segments, each of which can be taken out and replaced by others when the experiments show a change to be desirable. Heavy plate-glass walls make visible the action of the water not only on the dam but on the river bed as well. The latter is represented by a deep layer of gravel carefully graded to simulate actual conditions.

Designed especially for studying the problems of the Bonneville Dam, the Linnton Hydraulic Laboratory is of temporary construction. It covers about two acres of ground.

All work at the Bonneville project is being done by the Corps of Engineers, U. S. Army. J. C. Stevens, M. Am. Soc. C.E., is consulting engineer on these studies, and A. J. Gilardi, M. Am. Soc. C.E., is in charge of the laboratories. They have furnished the information for this article.



VIEW OF COMPLETED BONNEVILLE DAM, WHICH IS STILL UNDER CONSTRUCTION

Photographing a 1:100 Scale Model of the Bonneville Dam at a Height of 25 Ft Creates the Illusion of a Full-Sized Dam Seen from a Height of 2,500 Ft. The View Is Taken Looking Upstream. Bradford Island Is Reproduced in the Center Foreground. Fishways for Salmon Appear at Each End of the Left River Section

"And the Pins Came Back"

THE RECOVERY of an article that was thought to have been irrevocably lost is always very pleasing to the recipient, who usually has concluded more or less ruefully that he will never see it again. In fact, the pleasure derived is often in direct proportion to the odds against the article's return. Many anecdotes of varying degrees of credibility have arisen from such sources. In this connection it may be of interest to note the experiences of two entirely trustworthy members in the loss and recovery of their Society badges.

Theodore R. Kendall, M. Am. Soc. C.E., in May of this year had occasion to visit the Clendening Dam of the Muskingum conservancy project, in Ohio. While inspecting the borrow pit, the tunnel adits, and the site of the dam itself in the company of Robert F. Olds, M. Am. Soc. C.E., and Charles S. Joslyn, Assoc. M. Am. Soc. C.E., resident engineer for that portion of the work, Mr. Kendall lost his pin. The story continues in Mr. Kendall's words:

"The next day I realized that I had lost my Society pin, but where I could not guess. It was a real loss as the pin replaced one lost the previous year at the Eureka Underpass, Houston, Texas. The cause was the same, the strap of my camera undid the safety clasp and the pin popped off. I gave up the pin for lost and decided that it would be a long time before I invested in another, in spite of the fact that I am a believer in the wearing of the Society pin.

"Several weeks later Mr. Joslyn called me on the telephone while he was visiting New York and informed me that the pin was found the next day in the large borrow pit where several 12- and 14-yd wagons were running back and forth hauled by heavy tractors. These were being loaded by a 48-in. elevating grader. We considered it remarkable that such a small piece of jewelry should have been found, and that it was a Society member who was privileged to return it."

The second incident occurred to V. T. Boughton, M. Am. Soc. C.E., on a visit to a section of the Colorado Aqueduct at Berdoo camp, following the recent Los Angeles Convention. Mr. Boughton had pinned the Society badge onto his shirt before beginning the actual inspection. The subsequent events were as follows:

"The day was a full one. We ended up late in the evening at Los Angeles and spent the night in Mr. Kirkbride's car because we were leaving early for San Francisco. In the morning, forgetting the Society pin, I tucked the mussed shirt into my bag and at San Francisco sent it and others to the hotel laundry.

"I did not think of the pin again until I reached Seattle. Then I suddenly realized that I did not have it. Thinking back, I could not recall having it since the second day on the aqueduct, nor could I recall taking it off my shirt.

"I discovered that I still had the laundry slip, which I then sent off to the hotel in San Francisco with a note stating that I thought I had left the pin on a shirt covered by that slip. However, I had little hope of getting the pin back.

"On my return home some weeks later I found a letter from the hotel with my note written from Spokane enclosed—and pinned to it my Society pin!"

In the Footprints of the Conquistadores

POTOSÍ in Bolivia, on the northern slope of the Cerro Gordo de Potosí, 13,612 ft above sea level, was founded in 1547 under Charles V of Spain. Two years earlier an Indian had discovered silver on the *cerro*. But before the Spanish conquerors could make much headway in mining the ore it was necessary for their engineers to solve the water supply problem. William E. Rudolph, M. Am. Soc. C.E., who has recently completed the dam for a modern water supply, places the date of construction of the first lake at about 1575. Additional water was impounded during the period of Potosí's greatest prosperity, probably about 1611, after which silver production lessened and the mines began to be abandoned. Recent discoveries of valuable tin deposits have brought about renewed activity.

The Spanish engineers did their work well, says Mr. Rudolph in a recent letter to Past-President Ridgway, through whose courtesy this information has come to the attention of CIVIL ENGINEERING. Canals were used to carry the water to the mills of Potosí. Mr. Rudolph's sole criticism of the Spanish engineers' work is their failure to provide adequate spillway capacity. This may be explained, however, by the probable lack of records of the heavy downpours which occur at intervals in that region. The comparatively modern invention of pipe has made feasible the new water supply, since the early engineers had no means of crossing the deep valleys intervening between the new lake and the town. Incidentally the pipe now used was purchased second-hand from one of the New York City subway construction projects by Mr. Rudolph before he sailed for South America.

The new dam which Mr. Rudolph constructed of earth and clay on impervious masonry corewalls appeared light indeed compared to the massive structures of the Spaniards. At one time the municipal authorities expressed considerable concern for its safety, since Potosí has not forgotten the dark page in its history when, one Sunday afternoon in March 1626, the San Idlefonso Dam broke, drowning thousands and destroying the mills. However, since the authorities have seen the new lake nearly full, they seem satisfied that modern engineering methods may be right after all.

NEWS OF ENGINEERS

For Correspondence and Society Files

HAROLD NEVIN CAREY has severed his connection with the U. S. Coast and Geodetic Survey to join the staff of the South Dakota State Highway Commission in the capacity of junior resident engineer. His headquarters are in Mitchell, S.D.

FREDERICK H. FOWLER, consulting civil engineer of San Franciso, Calif., has been retained by the Flood Protection Committee of Greater Kansas City, to make a comprehensive study of the best plan for flood protection in the lower Kaw Valley in Kansas, including any necessary work along the Missouri River in protecting the greater Kansas City area.

EUGENE COUCH is now city engineer of Dallas, Tex., succeeding FRANCIS N. BALDWIN.

FRANK A. BELOUSEK has accepted the position of chief engineer for the Iowa State Conservation Commission, with offices in Des Moines, Iowa. He was previously assistant director of rural rehabilitation for the Iowa Emergency Relief Administration.

ROBERT B. B. MOORMAN has resigned as assistant professor of civil engineering at the University of Mississippi to accept a position in a similar capacity at the University of Missouri in Columbia, Mo.

J. W. MARKS has been promoted from the position of assistant supervisor of the Southern Railway Company to that of chief inspector in the Engineering Department of the same company, with headquarters in Tazewell, Tenn.

MELVIN A. DOBBS, who was formerly in the Illinois State Water Survey at Urbana, now holds the position of assistant sanitary engineer in the Illinois Department of Public Health. His offices are in Springfield.

L. C. TSCHUDY is now chief engineer in the Soil Conservation Service at Huron, S.D. He was previously supervising engineer in the U. S. Forest Service, with headquarters in Milwaukee, Wis.

FRANK A. WOODYARD recently opened an office as general contractor in the Bank of America Building in Beverly Hills, Calif. The firm of De Huff and Woodyard, Inc., of which Mr. Woodyard was formerly a member, has been dissolved.

E. A. BAUGH has accepted an appointment as Director of Projects and Planning for the Texas Works Progress Administration, with headquarters in San Antonio, Tex. He was formerly assistant director of the Texas Relief Commission.

WILLIAM E. DUCKERING is now professor of civil engineering and dean of faculty at the University of Alaska, at College, Alaska.

HENRY G. PEDRI has entered the employ of the Soil Conservation Service, Department of Agriculture, as engineer technician in a CCC camp at Horseshoe Bend, Idaho.

RICHARD KHUEN, JR., since his retirement from the American Bridge Company, has established a consulting engineering practice in the Frick Building in Pittsburgh, Pa.

Jean H. Knox has accepted an appointment as engineer for the Park Board of Dallas, Tex. He was formerly a consultant and bridge engineer for Dallas County.

A. G. Tsatsos resigned his position with John Monks and Sons—Ulen and Company of Serres, Greece, to accept an engineering connection with the Ertha Contracting Company of Athens, Greece.

A. V. Lynn recently resigned as assistant engineer of the Springfield (Mass.) Water Works to accept an appointment in a similar capacity in the General Engineering Division of the Tennessee Valley Authority, with headquarters in Paducah, Ky.

Albert L. Lane, Captain, Corps of Engineers, U. S. Army, has been transferred from the Port Isabel Harbor Development at Port Isabel, Tex., to Port Angeles, Wash.

B. D. Keatts completed his work with the Century of Progress Exposition on July 1, and is now employed in an engineering capacity by the Dur-Ite Company of Chicago, Ill., for which he will engage in the rehabilitation and waterproofing of concrete structures.

Neil Van Eenam, who was formerly with the Midland County (Michigan) Health Unit, has recently taken a position in the Bridge Department of the Michigan Central Railroad Company, with headquarters in Detroit, Mich.

John J. Jenkins, Jr., is now with the Wichert Continuous Bridge Corporation of Pittsburgh, Pa.

Mary O. Soroka has joined the staff of Air Devices of New York, 480 Lexington Avenue, New York, N.Y. She was previously with the Potomac Electric Power Company of Washington, D.C.

Robert B. Brooks, Jr., who has been working with the Dirrecion Nacional de Caminas of Mexico on the international highway between Laredo and Mexico City, resigned on completion of his work to become associated with his father, Robert B. Brooks, consulting engineer of St. Louis, Mo.

George S. Frost has taken an engineering position with the Public Service Commission of the State of Pennsylvania on valuation of the Philadelphia Rapid Transit System, with offices in Philadelphia.

William S. Post is now an inspector for the PWA. His headquarters are in Mather, Calif.

C. O. Clark, formerly in the employ of the Tennessee Valley Authority, is at present in the district office of the Wisconsin Emergency Relief Administration at Stevens Point, Wis., where he is designing small dams to be used in the control of ground-water and lake levels.

E. O. Sweetser, acting head of the Department of Civil Engineering at Washington University, was recently elected president of the Engineers' Club of St. Louis.

Alfred T. Waidelich has been promoted from the position of instructor in civil engineering at Robert College, Istanbul, Turkey, to that of assistant professor of civil engineering in the same institution.

Austin W. Brooks, formerly assistant construction engineer in the Madden Dam Division of the Panama Canal, has been transferred to the position of superintendent of the Northern District of the Municipal Engineering Division, with headquarters in Cristobal, Canal Zone.

Changes in Membership Grades

Additions, Transfers, Reinstatements, Deaths, and Resignations

From July 10 to August 9, 1935, Inclusive

Additions to Membership

Barker, Clifton Thorne (Assoc. M. '35), Hydr. Engr., TVA, New Sprankle Bldg., Knoxville, Tenn.

Bates, Clyde Noble (Assoc. M. '35), Sales Engr., Republic Cement Co., 1101 Smith-Young Tower, San Antonio, Tex.

Berman, Benjamin (M. '35), Deputy Chf. Engr., Triest Contr. Corporation, 578 Madison Ave., New York, N.Y.

Breslin, Thomas (Assoc. M. '35), Structural Eng. Asst., The Rand Water Board, 74 Commissioner St., Johannesburg, South Africa.

Brooks, Austin Whitney (M. '35), Supt., Northern Dist., Municipal Eng. Div., Panama Canal, Box 2012, Cristobal, Canal Zone.

Brumfield, Ray Carlton (M. '35), Asst. Prof., Civ. Eng., Cooper Union, New York (Res., 212 Rutland Rd., Freeport), N.Y.

Burritt, Edwin Wheeler (M. '35), State Engr., Box 443, Cheyenne, Wyo.

Capelle, Ernest Andrew (Jun. '35), Cultural Foreman, State Park Div., U. S. National Park Service, Letchworth State Park, S. P. 49, Castile, N.Y.

Chiarito, Americo Theodore (Jun. '35), 276 Ave. A, New York, N.Y.

Evans, Weston Sumner (M. '35), Prof., Civ. Eng., Univ. of Maine (Res., 8 Kell St.), Orono, Me.

Fortson, Eugene Palmer, Jr., (Jun. '35), Junior Engr., U. S. Waterways Experiment Station (Res., 1203 Harris St.), Vicksburg, Miss.

Foster, James Patrick (Jun. '35), Computer, U. S. Coast and Geodetic Survey, 641 Washington St., New York (Res., 140–71 Ash Ave., Flushing), N.Y.

Friberg, Bengt Frithiof (Assoc. M. '35), Engr., Laclede Steel Co., 1317 Arcade Building (Res., 4616 Lindell Boulevard), St. Louis, Mo.

Gavaris, Peter Theodore (Jun. '35), 667 Teasdale Pl., New York, N.Y.

Glendening, Paul Frederick (Jun. '35), Constr. Insp., State Highway Dept., Box 311, Globe, Ariz.

Gould, Carl Alvord (M. '35), Asst. Regional Engr., U. S. Forest Service (Res., 435 Humboldt St.), Denver, Colo.

TOTAL MEMBERSHIP AS OF AUGUST 9, 1935	
Members	5,718
Associate Members	6,176
Corporate Members	11,894
Honorary Members	17
Juniors	3,058
Affiliates	98
Fellows	2
Total	15,069

Gramatky, Ferdinand Gunner (Assoc. M. '35), Engr. on Constr., Jahn & Bressi Constr. Co., Inc., Los Angeles (Res., 336 South San Gabriel Boulevard, Pasadena), Calif.

Heilbron, Carl Henry, Jr., (Assoc. M. '35), Asst. Engr. (Design), Met. Water Dist. of Southern California (Res., 101 Mar Vista Ave.), Pasadena, Calif.

Hunt, Dudley Joseph (Assoc. M. '35), Engr., U. S. Bureau of Reclamation, New Custom House, Denver, Colo.

Jackson, LeRoy Hayine (Jun. '34), Insp. of Dredging, U. S. Engrs., Detroit Dist.; 711 Locust St., Toledo, Ohio.

Jewell, Henry Holmes (M. '35), Chf. Engr. Examiner for State Engr., PWA (Res., 185 Macalester Ave.), St. Paul, Minn.

Johnson, Arthur Delafield (Jun. '35), With J. H. Davies, Ocean Center Bldg., Long Beach (Res., 2465 Albatross St., San Diego), Calif.

Kahale, Soubhi (Jun, '35), Care, Public Works Dept., Amman, Transjordan.

Krauss, Wolfgang Walter (Assoc. M. '35), 1326 Harvard St., N.W., Washington, D.C.

MacKichan, Kenneth Allen (Jun. '35), 618 South Chestnut St., Lansing, Mich.

McClure, John Clarendon Englebright (M. '35), Special Engr., S. P. Co., Los Angeles (Res., 1140 Brent Ave., South Pasadena), Calif.

McKee, Hugh Thomas Peter (Jun. '35), Engr. and Supt., Cohoes Emergency Relief Bureau, Div. of TERA (Res., 205 Congress St.), Cohoes, N.Y.

Manes, Cole (Assoc. M. '35), City Engr., University Park (Res., 3725 Stanford Ave., Dallas), Tex.

MARTIN, HAROLD MELVILLE (Jun. '35), Junior Engr., U. S. Bureau of Reclamation (Res., 1135 South Grant St.), Denver, Colo.

MARTIN, JAMES BERNARD (M. '35), Director TERA, Borough Pres. of Brooklyn, Borough Hall, Brooklyn (Res., 4 Rochelle St., City Island), N.Y.

MOORE, ERNEST ARTHUR (Assoc. M. '35), Care Commonwealth Fund, 41 East 57th St., New York, N.Y.

MORTON, WILLIAM (Jun. '35), Levelman, U. S. Engrs., Bonneville Dam, Bonneville, Ore.

NOWICKI, LEO JOSEPH (Assoc. M. '35), Drain Commr., Wayne County, 3505 Barlum Tower, Detroit, Mich.

OGDEN, WILLIAM HALL (Assoc. M. '35), Mgr., Glen Cove Plant, New York Water Service Corporation (Res., 50 Glen St.), Glen Cove, N.Y.

PETTUS, LESLIE ALEXANDER (Assoc. M. '35), Div. Civ. Engr., City of St. Louis, 300 City Hall (Res., 5884 Cabanne), St. Louis, Mo.

QUICK, PHILLIP RUSSELL (Assoc. M. '35), Civ. Engr., W. A. Bechtel Co., Bechtel, Kaiser, Warren Co., Henry J. Kaiser Co., and Bridge Builders, Inc., San Francisco (Res., 1672 Oxford St., Berkeley), Calif.

QUIMBY, PAUL JAY (Assoc. M. '35), Engr., McClintic-Marshall Corporation (Res., 640 Fifteenth Ave.), Bethlehem, Pa.

QUIRK, WILLIAM HENRY (Jun. '35), Chf. Computer, New York City Parks Dept., Borough of Queens; 41-08 Parsons Boulevard, Flushing, N.Y.

ROAKE, THEODORE CHESTER (Jun, '35), Designer, State Highway Comm. (Res., 748 North 15th St.), Salem, Ore.

ROBINSON, PAUL THOMPSON (M. '35), Engr., M. of W. and Structures, S. P. Co., San Francisco (Res., 697 Arlington Ave., Berkeley), Calif.

RUTLEDGE, DWIGHT HANEY (Assoc. M. '35), Junior and Asst. Engr., Topographic Branch, U. S. Geological Survey, Box 346, Sacramento, Calif.

SCHIFF, LEONARD (Jun. '35), Junior Agricultural Engr., U. S. Soil Erosion Service, City Hall (Res., 905 Pleasant St.), Santa Paula, Calif.

SHACK, STEPHEN GEORGE (Jun. '35), 52 South 20th St., Pittsburgh, Pa.

SMITH, LOUIS ALEXANDER (Assoc. M. '35), Field Engr., Shell Oil Co., Wilmington (Res., 3576 Falcon Ave., Long Beach), Calif.

SMITS, HOWARD GARDNER (Jun. '35), Designer, with C. Deuel, 405 Douglas Bldg., Los Angeles (Res., 302 North Maryland, Glendale), Calif.

TAROF, ERNEST LIVINGSTON (Assoc. M. '35), Chf. Engr. (Kerlow Steel Flooring Co.), 222 Culver Ave., Jersey City, N.J. (Res., 1146 East 2d St., Brooklyn, N.Y.)

TAYLOR, COLIN ALEXANDER (Assoc. M. '35), Asst. Irrig. Engr., Div. of Irrig., Bureau of Agri. Eng., U. S. Dept. of Agriculture, Room 4, Post Office Bldg., Pomona, Calif.

TERRILL, DUDLEY RUSSELL (Assoc. M. '35), Asst. Engr., State Highway Dept., Cleveland (Res., 179 Stanford Rd., Berea), Ohio.

THOMAS, CHARLES WALTER (Jun. '35), Care, Bureau of Reclamation, Montrose, Colo.

VAN DUYNE, RICHARD (Assoc. M. '35), Asst. Engr., TERA (Works Div.), 111 Eighth Ave., New York (Res., 11-20 Fiftieth Ave., Long Island City), N.Y.

WUOPIO, FRANS ALBERT (Assoc. M. '35), Asst. Topographic Engr., U. S. Geological Survey, Box 346, Sacramento, Calif.

MEMBERSHIP TRANSFERS

BARBER, RICHARD (Jun. '30; Assoc. M. '35), Res. Engr., State Dept. of Highways, 1120 Pacific, Everett, Wash.

BURNS, CHARLES PHILLIPS (Jun. '31; Assoc. M. '35), Project Engr., U. S. Bureau of Public Roads, Fishing Bridge Station, Yellowstone Park, Wyo. (Res., 2525 Clay St., Denver, Colo.)

CARTER, ROBERT LAYTON (Jun. '28; Assoc. M. '35), Structural Designer, Oregon-Washington Bridge Co., Security Bldg. (Res., 1018 Adams St.), Olympia, Wash.

CLEMENT, EDWARD DAWSON (Assoc. M. '29; M. '35), Pres., Clement Constr. Co., 9 State St., Charleston, S.C.

CRANE, ALBERT ELI (Assoc. M. '17; M. '35), Vice-Pres., T. E. Rhoades Co., Inc., 342 Madison Ave., New York, N.Y.

EVANS, LEONARD THOMAS (Jun. '26; Assoc. M. '35), Cons. Structural Engr., 1982 Pasadena Ave., Long Beach, Calif.

FRICK, WALTER HIRAM (Assoc. M. '31; M. '35), Cons. Structural Engr. (Architectural), 607 Hampton Ave., Wilkinsburg, Pa.

GAMBLE, RALEIGH WELCH (Assoc. M. '24; M. '35), Supt., Bureau of Street Constr. and Repairs, City Hall, Milwaukee, Wis.

GARDNER, GEORGE WASHINGTON (Jun. '17; Assoc. M. '20; M. '35), Civ. Engr. and Surv.; Village Engr. (Res., 56 Collins St.), Lowville, N.Y.

GERDES, HENRY GEORGE (Jun. '22; Assoc. M. '29; M. '35), Engr., Federal Power Comm., Washington, D.C.

GROMFINE, JOHN JACOB (Assoc. M. '24; M. '35), Lt.-Commander, C.E.C., U.S.N., Norfolk Navy Yard, Portsmouth, Va.

GOODHUE, HOWARD WILLIAM (Jun. '25; Assoc. M. '35), Asst. Engr., Pasadena Water Dept. (Res., 920 East Howard St.), Pasadena, Calif.

HANSEN, JAMES HAROLD (Jun. '30; Assoc. M. '35), Secy.-Mgr., Brick Mfrs. Assoc. of New York, 1716 Grand Central Terminal (Res., 141 East 44th St.), New York, N.Y.

HERTHE, NORMAN MATTHEW (Assoc. M. '28; M. '35), Valuation Engr. (Ellsworth, Barrows & Co.), 2022 Liberty Bank Bldg., Buffalo, N.Y.

HUMMER, JOHN WILLIAM (Jun. '25; Assoc. M. '35), Asst. Valuation Engr., The United Light and Power Eng & Constr. Co., 302 United Light Bldg., Davenport, Iowa.

JENS, STIFEL WILLIAM (Jun. '32; Assoc. M. '35), Asst. Engr., W. W. Horner, International Office Bldg., St. Louis (Res., 7028 Kingsbury Boulevard, University City), Mo.

JOHNSON, CLIFFORD (Assoc. M. '26; M. '35), Bridge Engr., State Dept. of Highways, Box 481, Bismarck, N.Dak.

KAMPF, MORRIS (Assoc. M. '28; M. '35), Cons. Engr., 31 Union Sq., West (Res., 331 East 17th St.), New York, N.Y.

KANE, CLYDE VERNON (Jun. '27; Assoc. M. '35), Associate Highway Engr., State Div. of Highways, 256 East 19th St., San Bernardino, Calif.

KEELY, CHARLES CLARKE (Jun. '26; Assoc. M. '35), Asst. Commercial Operations Engr., Associated Telephone Utilities Co., Inc., 550 Elm Ave., Long Beach (Res., 1710 Buckingham Rd., Los Angeles), Calif.

KNIESTEDT, EWALD MATTHEW (Jun. '26; Assoc. M. '35), Engr. in Chg., Engr. Section U. S. Engrs. Office, 428 Customhouse, St. Louis, Mo.

LAIDLAW, DOUGLAS STAUNTON (Jun. '32; Assoc. M. '35), Structural Engr., 68 King St., East Toronto 2, Ont., Canada.

LEACH, WALTER LEWIS (Jun. '24; Assoc. M. '28; M. '35), Designing Engr., George B. Gascoigne, 1140 Leader Bldg., Cleveland, Ohio.

LYONS, EMANUEL, JR. (Jun. '28; Assoc. M. '35), Civ. Engr. (Buckley, Arango & Lyons), 27 Avenida Central, Panama, Panama.

MILLS, HENRY JOHN (Jun. '28; Assoc. M. '35), Res. Engr., Met. Water Dist. of Southern California; Care, J. F. Shea Co., Indio, Calif.

MORSE, ROY WINCHESTER (Jun. '28; Assoc. M. '35), Asst. Engr., W. C. Morse Co., 2126 Smith Tower (Res., 2733 Belvidere Ave.), Seattle, Wash.

ONDRUS, THOMAS (Jun '33; Assoc. M. '35), Div. Engr's Office, C M. St. P. & P. R. R., Marion, Iowa.

O'SHEA, DANIEL GEORGE (Jun. '26; Assoc. M. '35), Asst. Engr., U S Bureau of Reclamation, Customhouse, Denver, Colo.

PROT, WERNER ANTHONY (Jun. '31; Assoc. M. '35), Draftsman, Class A, Sewerage Comm., City of Milwaukee (Res., 3614 North 41st St.), Milwaukee, Wis.

POLLARD, CHARLES JASPER (Assoc. M. '28; M. '35), Valuation Engr. (Ellsworth, Barrows & Co.), 2022 Liberty Bank Bldg., Buffalo, N.Y.

REYNOLDS, THOMAS GEORGE (Jun. '28; Assoc. M. '35), Asst. Res. Engr., Continental Oil Co. (Res., 420 South Palm St.), Ponca City, Okla.

RINEHART, GERALD STAATS (Assoc. M. '21; M. '35), With PWA, Box 172, Buchanan, N.Y.

ROOS, SIGMUND (Jun. '29; Assoc. M. '35), 334 West 85th St., New York, N.Y.

SAWTELLE, EGERTON BURPEE (Jun. '32; Assoc. M. '35), Junior Engr., State Highway Comm., State House (Res., 55 Capitol St.), Augusta, Me.

SCHROEDER, FRANK CHARLES (Assoc. M. '12; M. '35), Chf. Draftsman, Way and Structures Dept., The Milwaukee Elec. Ry. and Light Co. (Res., 709 East Juneau Ave.), Milwaukee, Wis.

STUART, JAMES LYALL (Jun. '98; Assoc. M. '00; M. '35), Const. Engr., 519 Oliver Bldg., Pittsburgh, Pa.

VAN VALKENBURGH, HAROLD THUNIS (Jun. '26; Assoc. M. '35), Engr., Texas Power & Light Co., Dallas, Tex.

WALTER, CARL EMIL (Jun. '26; Assoc. M. '35), Senior Engr., CCC, Camp S 52, Grantsville (Res., 519 Nottingham Rd., Ten Hills, Baltimore), Md.

WARD, WILLIAM BERNARD (Assoc. M. '24; M. '35), Archt. (Tietig & Lee), 34 West 6th St., Cincinnati, Ohio.

YASINES, STAN FRANZ (Jun. '29; Assoc. M. '35), Instr. in Civ. Eng., Coll. of Eng., New York Univ. (Res., 106 West 179th St.), New York, N.Y.

REINSTATEMENTS

BADGLEY, BEN OLIVER, Assoc. M., reinstated Aug. 9, 1935.

BENFIELD, ABEL MORRIS, M., reinstated Aug. 2, 1935.

BIRNBAUM, HARRY, Jun., reinstated Aug. 2, 1935.

FIELD, HUGH TOWNSEND, Assoc. M., reinstated Aug. 1, 1935.

FLOYD, RICHARD ARCHIBALD, Assoc. M., reinstated Aug. 6, 1935.

HASKELL, FRANK HAMPTON, M., reinstated July 15, 1935.

MURRELL, JOHN WILLIAM, Assoc. M., reinstated July 26, 1935.

PILLET, FREDERICK FISCHER, M., reinstated July 16, 1935.

POPPE, CHARLES RAYMOND, Jun., reinstated July 16, 1935.

STEEG, HENRY BELL, Assoc. M., reinstated July 15, 1935.

RESIGNATIONS

BALDWIN, GEORGE CLYDE, M., resigned July 9, 1935.

BURRELL, CECIL LLOYD, Jun., resigned July 18, 1935.

CUTCHIN, BRAXTON MURRAY, JR., Jun., resigned July 30, 1935.

ENGSTROM, LEONARD MICHAEL, Jun., resigned Aug. 2, 1935.

FAIRCLOTH, JAMES MANNING, Jun., resigned Aug. 2, 1935.

NORFORD, VIRGIL HAROLD, Jun., resigned July 12, 1935.

Deaths

ASHWORTH, FRANK KARR. Elected Assoc. M. June 18, 1918; died July 24, 1935.

BUZBY, ARTHUR DUDLEY. Elected Assoc. M. Nov. 25, 1919; M. Oct. 21, 1924; died May 26, 1935.

HANSFORD, MORRIS. Elected M. Jan. 14, 1924; died July 17, 1935.

HEINE, JOHN GEORGE. Elected M. June 19, 1922; died May 6, 1935.

HENNY, DAVID CHRISTIAAN. Elected M. Sept. 7, 1887; died July 14, 1935.

LELAND, FRANKLIN EDWARD. Elected Assoc. M. June 6, 1921; died July 8, 1935.

LINDENTHAL, GUSTAV. Elected M. May 3, 1882; Hon. M. Oct. 7, 1929; died July 31, 1935.

MULHOLLAND, WILLIAM. Elected M. Feb. 6, 1907; died July 22, 1935.

MURCHISON, EDWARD TOWLER. Elected Assoc. M. April 3, 1922; M. Dec. 26, 1933; died May 8, 1935.

ROSECRANS, WILLIAM HENRY. Elected M. Oct. 5, 1898; date of death unknown.

SHEPHERD, FRANK CUMMINGS. Elected Assoc. M. Oct. 5, 1904; M. Feb. 1, 1910; died Aug. 6, 1935.

SIBBONS, GORDON EARL. Elected Assoc. M. Oct. 14, 1930; died July 31, 1935.

YARDLEY, RALPH WALDO. Elected Assoc. M. Aug. 4, 1924; date of death unknown.

Applications for Admission or Transfer

Condensed Records to Facilitate Comment of Members to Board of Direction

September 1, 1935 NUMBER 9

The Constitution provides that the Board of Direction shall elect or reject all applicants for admission or for transfer. In order to determine justly the eligibility of each candidate, the Board must depend largely upon the membership for information.

Every member is urged, therefore, to scan carefully the list of candidates published each month in CIVIL ENGINEERING *and to furnish the Board with data which may aid in determining the eligibility of any applicant.*

It is especially urged that a definite recommendation as to the proper grading be given in each case, inasmuch as the grading must be based upon the opinions of those who know the applicant personally as well as upon the nature and extent of his professional experience. Any facts derogatory to the personal character or professional reputation of an applicant should be promptly communicated to the Board.

Communications relating to applicants are considered strictly confidential.

The Board of Direction will not consider the applications herein contained from residents of North America until the expiration of 30 days, and from non-residents of North America until the expiration of 90 days from the date of this list.

MINIMUM REQUIREMENTS FOR ADMISSION

GRADE	GENERAL REQUIREMENT	AGE	LENGTH OF ACTIVE PRACTICE	RESPONSIBLE CHARGE OF WORK
Member	Qualified to design as well as to direct important work	35 years	12 years*	5 years of important work
Associate Member	Qualified to direct work	27 years	8 years*	1 year
Junior	Qualified for sub-professional work	20 years †	4 years*	
Affiliate	Qualified by scientific acquirements or practical experience to cooperate with engineers	35 years	12 years*	5 years of important work
Fellow	Contributor to the permanent funds of the Society			

* Graduation from an engineering school of recognized reputation is equivalent to 4 years of active practice.

† Membership ceases at age of 33 unless transferred to higher grade.

The fact that applicants refer to certain members does not necessarily mean that such members endorse.

FOR ADMISSION

BAKER, ROBERT CLINTON, Tucson, Ariz. (Age 53.) Project Mgr. (Chf. Engr.) for Pima County Work Div., CWA-FERA. Refers to E. S. Borgquist, W. S. King, B. R. Metcalf, J. H. Rider, J. R. Van Horn.

BATES, FRANCIS, JR., Los Angeles, Calif. (Age 25.) Instrumentman, Metropolitan Water Dist. of Southern California. Refers to G. E. Baker, H. R. Bolton, N. Bostwick, R. B. Diemer, P. F. Gemperle, A. Jones, R. J. Reed.

BEAUPAIN, WILLIAM EMERSON, South Norwalk, Conn. (Age 21.) Refers to E. R. Cary, L. W. Clark, H. B. Compton, T. R. Lawson, H. O. Sharp.

BEEBE, JOHN CLEAVELAND, San Francisco, Calif. (Age 49.) Senior Civ. Engr., U. S. Forest Service. Refers to E. E. Blackie, E. C. Eaton, W. L. Huber, E. W. Kramer, W. A. Perkins, I. C. Steele, F. H. Tibbetts.

BIRCH, GEORGE WASHINGTON, Hyrum, Utah. (Age 22.) With U. S. Reclamation Service, Hyrum Project. Refers to G. D. Clyde, O. W. Israelsen, R. B. West.

BJORNSTAD, TRYGVE, Seattle, Wash. (Age 22.) Refers to G. E. Hawthorn, R. G. Hennes, C. C. May, C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

BLANK ROTH, CESAR AUGUSTO, Troy, N.Y. (Age 26.) Refers to L. W. Clark, H. O. Sharp.

BLASCHKE, EDWIN HENRY, Austin, Tex. (Age 21.) Refers to P. M. Ferguson, J. A. Focht.

BRACHT, BEREND, JR., Chattanooga, Tenn. (Age 22.) Refers to L. Mitchell, S. D. Sarason.

BRANDS, MAURICE DWANE, Portland, Ore. (Age 21.) Refers to J. R. Griffith, F. Merryfield, C. A. Mockmore.

BRANSON, WALTER EUGENE, Pittsburgh, Pa. (Age 24.) Refers to C. G. Dunnells, F. J. Evans, C. B. Stanton.

BRITTEN, HUDSON NEIL, Woodland, Ariz. (Age 22.) Surveyor, Geophysical Research Corporation. Refers to F. S. Foote, C. G. Hyde.

BROOKS, DAVID CHASE, Newport, R.I. (Age 24.) Refers to C. D. Billmyer, J. L. Murray.

BURNS, BENNETT WINFIELD, Houston, Tex. (Age 21.) Refers to L. B. Ryon, Jr., L. V. Uhrig.

BURT, GORDON LANSING, Savanna, Ill. (Age 22.) Rodman, Chicago, Milwaukee, St. Paul & Pacific R.R. Co. Refers to R. E. Hutchins, R. L. McCormick.

BUSSE, ROBERT RAMSEY, Pittsburgh, Pa. (Age 23.) Refers to H. S. Ayres, C. G. Dunnells, F. J. Evans, F. M. McCullough, C. B. Stanton, H. A. Thomas.

BUTLER, EARLE BENNETT, Norris, Tenn. (Age 23.) Under Eng. Aide, Hydr. Laboratory, TVA. Refers to R. E. Hutchins, R. L. McCormick.

BUZO, ZIHNI JUSUF, Montgomery, Ala. (Age 21.) Refers to B. A. Etcheverry, G. M. Fair A. Haertlein, C. G. Hyde, H. M. Turner.

CAHOON, JAMES WAYNE, Magna, Utah (Age 25). Draftsman, Utah Agricultural Experiment Station, Logan, Utah. Refers to G. D. Clyde, O. W. Israelsen, H. R. Kepner, R. B. West.

CAMBELL, CHESTER WENDELL, Gray, Maine. (Age 33.) Examining Engr. PWA, Washington, D.C. Refers to R. H. Chambers, H. S. Devlin, G. L. Freeman, H. P. Hevenor, G. R. Johnson, C. M. Leahy, C. McDonough.

CAMPBELL, THOMAS COLIN, New York City. (Age 44.) Gen. Mgr., Tudor City development, Fred F. French Management Co., Inc. Refers to A. E. Crane, A. D. Crosett, J. A. Olson, E. Praeger, G. A. Sherron.

CANEVA, BRUNO, New York City. (Age 21.) Refers to R. E. Goodwin, F. O. X. McLoughlin, J. C. Rathbun.

CARMAN, HARRY BLAINE, JR., Bloomfield, N.J. (Age 22.) Refers to H. C. Bird, W. H. Hall.

CLARE-JIMENEZ, MANUEL EMILIO, San Jose, Costa Rica. (Age 23.) Refers to R. P. Black, C. D. Gibson, W. A. Hansell, J. H. Johnston, F. C. Snow.

CLARK, JAMES GORDON, Kansas City, Mo. (Age 21.) Refers to J. J. Doland, T. C. Shedd.

COAN, JOHN MICHAEL, JR., Baltimore, Md. (Age 20.) Refers to J. H. Gregory, J. T. Thompson.

COMER, JOHN WILLIAM, Midwest, Wyo. (Age 21.) Refers to J. E. Kirkham, E. R. Stapley.

CORDON, WILLIAM ALFRED, Rigby, Idaho (Age 22.) Refers to G. D. Clyde, O. W. Israelsen, H. R. Kepner, R. B. West.

Corey, John Burhyte Wilmot, Jr., Seattle, Wash. (Age 23.) Refers to C. W. Harris, C. C. May, C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

Corser, Champ Elkins, Seattle, Wash. (Age 28.) Refers to C. W. Harris, G. W. Hawthorn, C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

Cranley, Edward Patrick, Chicago, Ill. (Age 26.) Refers to J. G. Bennett, F. G. Gordon.

Crowley, John Bernard, New York City. (Age 26.) Draftsman and Squad Leader with Gibbs & Hill, Inc. Refers to E. H. Anson, A. D. Fields, P. A. Kelly, F. Rullan, W. Vredenburgh.

Ctel, James Eugene, Jr., Waynesville, N.C. (Age 22.) Levelman, North Carolina State Highway Dept. Refers to W. G. Geile, C. L. Mann, H. Tucker.

Dallas, Alexander Fraser, New Dorp, N.Y. (Age 22.) Refers to L. W. Clark, T. R. Lawson.

Davidson, Leo, Chattanooga, Tenn. (Age 21.) Refers to L. Mitchell, S. D. Sarason.

De Meo, Lawrence John, Lexington, Ky. (Age 25.) Jun. Office Engr. with J. S. Watkins. Refers to E. M. Hastings, P. A. Rice.

Dodds, Arthur Earnest William, Seattle, Wash. (Age 27.) On work for Farwest Speedways, Inc., near Seattle. Refers to I. L. Collier, G. E. Hawthorn, C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

Dodson, Virgil Ivan, Toledo, Ohio. (Age 28.) With U. S. Engr. Dept. Refers to C. E. S. Bardsley, J. B. Butler, E. W. Carlton.

Dominy, John Arthur, Bay Shore, N.Y. (Age. 23.) Supt., at Port Socony, N.Y., for Perlman & Wortmann, Inc., New York City. Refers to E. R. Cary, L. W. Clark, H. B. Compton, T. R. Lawson, H. O. Sharp.

Donaldson, Howard William, Polo, Ill. (Age 23.) Refers to J. G. Bennett, F. G. Gordon.

Downing, Francis John, Buffalo, N.Y. (Age 41.) Dist. Director, WPA, N.Y. State. Refers to L. E. Andrews, E. M. Fleming, J. T. Mockler, S. S. Neff, T. M. Ripley, E. G. Speyer.

Downing, Robert Woodling, Ben Avon, Pa. (Age 21.) Refers to R. H. Suttie, J. C. Tracy.

Duerr, Arlie William, Orrville, Ohio. (Age 28.) Refers to E. F. Berry, S. D. Sarason.

Enger, Walter Melvin, Denver, Colo. (Age 21.) Jun. Engr., Bureau of Reclamation. Refers to J. J. Doland, W. C. Huntington, T. C. Shedd.

Englund, Oscar Edmund, Stanchfield, Minn. (Age 26.) Refers to F. Bass, A. S. Cutler, O. M. Leland, L. G. Straub.

Enkeboll, William, Bremerton, Wash. (Age 22.) Refers to C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

Feige, Henry Theinert, Oaklyn, N.J. (Age 25.) Refers to W. H. Barton, Jr., C. E. Myers.

Ferver, Greer Wilson, San Luis Obispo, Calif. (Age 21.) Draftsman, Union Oil Co. of Calif. Refers to A. L. Ferver, R. R. Martei, F. Thomas, R. D. Van Alstine.

Flint, Raymond Eugene, Webster Groves, Mo. (Age 22.) Refers to W. W. Horner, E. O. Sweetser.

Forsyth, Benjamin, Brooklyn, N.Y. (Age 29.) Refers to R. E. Goodwin, J. C. Rathbun.

Frazer, James Gardner, Seattle, Wash. (Age 23.) Refers to I. L. Collier, R. G. Hennes, C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

Friedlaender, Hermann, Seattle, Wash. (Age 28.) Refers to G. E. Hawthorn, C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

Frost, George Walker, Nantucket, Mass. (Age 22.) Refers to L. W. Clark, H. O. Sharp.

Gambrell, James Wyatt, Columbia, S.C. (Age 21.) Computer, South Carolina Local Control Survey. Refers to R. C. Johnson, W. E. Rowe, R. L. Sumwalt.

Gattmann, Reed, Los Angeles, Calif. (Age 22.) Refers to R. M. Fox, J. Hines, A. E. Sedgwick, D. M. Wilson.

Gegauff, Gustav, Union, N.J. (Age 24.) Refers to R. P. Black, F. C. Snow.

Gill, Samuel Chriswell, Jr., Piedmont, Mo. (Age 22.) Jun. Civ. Engr., Missouri State Game & Fish Dept., Forest CCC Camp. Refers to A. L. Hyde, H. K. Rubey.

Grasier, Frederick Arden, Gladstone, Ore. (Age 26.) Refers to J. R. Griffith, C. A. Mockmore.

Graves, Richard Wadsworth, Albany, N.Y. (Age 25.) Refers to P. S. Dow, F. W. Garran, A. W. Harrington, H. F. Hill, C. A. Holden.

Grebner, Ronald George, Topeka, Kans. (Age 22.) Jun. Asst. Draftsman, Kansas State Highway Comm. Refers to M. W. Furr, L. V. White.

Greiner, Kenneth Frederic, Hibbing, Minn. (Age 25.) Refers to F. Bass, A. S. Cutler, O. M. Leland, L. G. Straub, W. H. Wheeler.

Grill, William Henry, New York City. (Age 20.) Refers to C. T. Schwarze, D. S. Trowbridge.

Hall, Paul, Dallas, Tex. (Age 22.) With Austin Bridge Co. Refers to J. H. Murdough, G. W. Parkhill, H. N. Roberts.

Ham, Cavis Beecher, Denver, Colo. (Age 23.) Rodman, Moffat Water Tunnel Project. Refers to R. L. Downing, F. R. Dungan, C. L. Eckel, E. W. Raeder, W. H. Thoman.

Harder, Bernard Samuel, Los Angeles, Calif. (Age 30.) Engr., Los Angeles County Sanitation Dists. Refers to E. A. Burt, C. R. Compton, R. M. Fox, T. J. Leahy, G. F. Nicholson, H. K. Palmer, A. M. Rawn, A. K. Warren, D. M. Wilson.

Hattrup, Richard Adolph, San Francisco, Calif. (Age 24.) Jun. Engr., Eng. Dept., Standard Oil Co. of California. Refers to J. M. Evans, E. L. Grant, H. H. Hall, L. B. Reynolds, E. C. Thomas, J. B. Wells, S. K. Whipple.

Hayden, George Gunderson, Bronxville, N.Y. (Age 26.) Refers to E. Anderberg, J. Downer, A. G. Hayden, L. G. Holleran, L. R. Stuffler.

Heaman, William McPherson, Portland, Ore. (Age 25.) With National Tank & Pipe Co., Portland, Ore. Refers to I. L. Collier, L. Griswold, C. W. Harris, G. E. Hawthorn, C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

Hegge, Fritdjov Doran, Seattle, Wash. (Age 24.) Refers to I. L. Collier, C. C. May, C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

Hill, Gordon Travis, Newsome, Tex. (Age 22.) Refers to J. T. L. McNew, J. J. Richey.

Hofmann, Arnold, Clifton, N.J. (Age 22.) Refers to E. R. Cary, T. R. Lawson, W. W. Rousseau, H. O. Sharp.

Hollis, Edward Poole, Cambridge, Mass. (Age 27.) Refers to G. M. Fair, A. Haertlein, A. T. Safford, H. M. Turner.

Hopps, John Philip, Ross, Calif. (Age 29.) Refers to R. A. Beebee, C. F. Calhoun, A. Huber, F. B. Smith, J. W. Williams.

Howard, James Murray, Harrisburg, Pa. (Age 21.) Refers to C. A. Ellis, R. B. Wiley.

Ippen, Arthur Thomas, Pasadena, Calif. (Age 28.) Teaching Fellow and Asst. in Hydr. Mech. Eng. Dept., California Inst. of Technology. Refers to R. R. Martel, F. T. Mavis, W. W. Michael, F. Thomas, T. von Karman, C. C. Williams, S. M. Woodward.

Ivory, William Edward, Norwich, N.Y. (Age 23.) Draftsman, Norwich Pharmacal Co. Refers to W. J. Farrisee, F. C. Wilson.

Jancik, Edward Charles, Jasper, Tex. (Age 28.) Inspector, Texas State Highway Dept. Refers to R. C. Black, G. A. Bracher, C. H. Kendall, J. T. L. McNew, J. J. Richey.

Johnston, Clair Crawford, Detroit, Mich. (Age 36.) Prof., Civ. Eng. Dept., Univ. of Detroit, Detroit, Mich. Refers to E. L. Eriksen, P. A. Fellows, J. M. Mudie, C. J. J. Pajot, R. H. Sherlock, H. A. Shuptrine, W. S. Wolfe.

Jones, Carl Roemer, Berkeley, Calif. (Age 30.) Refers to C. Derleth, Jr., B. Jameyson, M. P. O'Brien.

Jones, Morris Shelley, Pasadena, Cal. (Age 48.) Asst. Chf. Engr., Pasadena Water Dept. Refers to T. D. Allin, E. S. Borgquist, H. P. Cortelyou, S. B. Morris, W. Putnam, C. W. Sopp.

Jordan, Donald Thomas, San Francisco, Calif. (Age 22.) Cable Spinner, San Francisco-Oakland Bay Bridge. Refers to A. P. Boysen, H. C. Hunter, T. A. Jordan, N. D. Morgan, C. E. Palmer, A. F. Reichmann, C. E. Webb.

Jorgensen, Homer William, Paso Robles, Calif. (Age 20.) Refers to C. Derleth, Jr., C. G. Hyde.

Joseph, Louis Wyman, Little Neck, N.Y. (Age 38.) Asst. Engr. with Gibbs & Hill, New York City. Refers to E. H. Anson, D. Y. Dimon, A. D. Fields, P. A. Kelly, F. Rullan.

Kantor, Nathan, Chattanooga, Tenn. (Age 20.) Refers to E. F. Berry, L. Mitchell.

Kelly, Edmonde Bernard, New York City. (Age 25.) Inventory Asst. (Eng.) Consolidated Gas Co., Constr. Div. Refers to C. B. Ferris, R. H. Jacobs, A. P. Richmond, Jr., C. T. Schwarze, D. S. Trowbridge.

Kimball, Jack Haven, Burlingame, Calif. (Age 22.) San. Engr., Palo Alto Sewage-Treatment Plant, being Chf. Operator. Refers to J. F. Byxbee, C. G. Hyde.

Kindsvater, Carl Edward, Hoisington, Kans. (Age 22.) Refers to G. W. Bradshaw, J. O. Jones, W. C. McNown, F. A. Russell.

King, Russell Earle, Clemson, S.C. (Age 21.) Refers to E. L. Clarke, D. D. Curtis, H. E. Glenn.

King, Walter Winburne, Jr., Greensboro, N.C. (Age 21.) Refers to H. G. Baity, T. F. Hickerson.

Komora, Andrew Mitchell, Norris Tenn. (Age 33.) Office Engr., Norris Dam, TVA. Refers to A. J. Ackerman, D. A. Davis, R. E. Everett, R. A. Galbreath, B. M. Jones, E. Maerker, C. D. Riddle.

Krasnodebski, Casimir, Brooklyn, N.Y. (Age 21.) Refers to A. Haring, C. T. Schwarze, D. S. Trowbridge.

Kroup, Benjamin Adam, Amsterdam, N.Y. (Age 26.) Refers to E. R. Cary, H. W. DeGraff, T. R. Lawson.

Laird, Arthur Edward, Natchez, Miss. (Age 24.) Topographic Draftsman, U. S. Engr. Dept. Refers to F. W. Jennings, C. T. Morris, R. C. Sloane.

Langmus, George William, New York City. (Age 22.) Engr. with Frederick S. Keeler, Archt., New York City. Refers to A. H. Beyer, J. K. Finch, W. J. Krefeld.

Lawrence, Fred Forrest, Tacoma, Wash. (Age 22.) Refers to H. E. Phelps, M. K. Snyder, J. G. Woodburn.

Lee, Fred, Roswell, N. Mex. (Age 22.) Refers to P. M. Ferguson, J. A. Focht.

Leisch, Jack Eugene, Baltimore, Md. (Age 22.) Refers to J. H. Gregory, J. T. Thompson.

Levy, Albert MacCullough, Oak Park, Ill. (Age 23.) Refers to J. J. Doland, W. C. Huntington.

Lewin, Joseph David, Brooklyn, N.Y. (Age 29.) Refers to B. A. Bakhmeteff, E. H. Burroughs, Jr., J. K. Finch, R. E. Goodwin, S. W. Stewart.

Lippis, Rocco Louis, Seattle, Wash. (Age 25.) Refers to I. L. Collier, G. E. Hawthorn, C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

Lopez De Romana, Eduardo Carlos, Arequipa, Peru. (Age 24.) Refers to R. A. Caughey, A. H. Fuller, W. E. Galligan, F. Kerekes, R. A. Moyer.

LOVE, ANDREW CAVITT, Ennis, Tex. (Age 59.) Res. Engr., State Highway Dept. Refers to T. L. Bell, Jr., F. E. Giesecke, G. Gilchrist, J. T. L. McNew, J. J. Richey, A. P. Rollins, O. A. Seward, Jr., T. B. Warden, M. C. Welborn.

MACMURRAY, LLOYD CHARLES, Oakland, Md. (Age 23.) Refers to T. F. Hubbard, J. T. Thompson.

MCCARTHY, JOHN FRANCIS, Brooklyn, N.Y. (Age 22.) Refers to H. R. Codwise, L. F. Rader, E. J. Squire.

MCGRATH, RAYMUND VINCENT, Seattle, Wash. (Age 23.) Refers to I. L. Collier, G. E. Hawthorn, C. W. McMorris, C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

MCNAIR, JAMES ELBREDGE, Columbia, S.C. (Age 21.) Refers to R. C. Johnson, W. E. Rowe.

MCNAIRY, WYATT HAMILTON, Winston-Salem, N.C. (Age 21.) Student Apprentice, Southern Ry. Co. Refers to T. F. Hickerson, R. M. Trimble.

MCRAE, ROBERT ALEXANDER, Los Angeles, Calif. (Age 21.) Instrumentman, Pacific Elec. Ry. Co., Los Angeles, Calif. Refers to R. R. Martel, W. W. Michael, F. Thomas.

MALCHOW, CARTER DANA, Longmont, Colo. (Age 26.) Instrumentman, Colorado Highway Dept. Refers to R. L. Downing, F. R. Dungan, C. L. Eckel.

MANDRY, JAMES ELMER, Logan, Utah (Age 23.) Refers to G. D. Clyde, O. W. Israelsen, H. R. Kepner, R. B. West.

MEADS, JOHN HERBERT, Washington, D.C. (Age 21.) Refers to H. G. Avers, J. R. Lapham.

MENDES, FRANK HAROLD, Baldwin, N.Y. (Age 31.) Chf. Draftsman, Empire City Subway Co., Ltd., New York City. Refers to H. Grant, J. J. Knox, R. W. Lefavour, A. T. Moran, C. I. Walker, F. N. Weaver, E. H. Wright.

MILLIKAN, OLIVER HARVEY, Boulder, Colo. (Age 26.) Instrumentman, Boulder County ERA. Refers to E. O. Bergman, R. L. Downing, F. R. Dungan, C. L. Eckel, E. W. Raeder, C. H. Sievers.

MOAT, HARRY ERNEST, Kingston, Pa. (Age 23.) Refers to W. R. Benford, S. Wilmot.

MORGAN, ELMO RICH, Salt Lake City, Utah. (Age 22.) Refers to G. D. Clyde, O. W. Israelsen, H. R. Kepner, R. B. West, L. M. Winsor.

MORRISON, WILLIAM WOODROW, Hinton, W.Va. (Age 22.) Refers to R. P. Black, F. C. Snow.

MYERS, EARL COLEMAN, JR., San Diego, Calif. (Age 21.) Engr., Sugar Beet Production Control Association, U. S. Dept. of Agriculture. Refers to R. E. Davis, C. Derleth, Jr., C. G. Hyde.

NELSON, LEE EDWARD, Allerton, Iowa (Age 22.) Refers to R. A. Caughey, J. S. Dodds, A. H. Fuller, W. E. Galligan, F. Kerekes, L. O. Stewart.

NETZER, BENNIE NATHAN, Pittsburgh, Pa. (Age 22.) Refers to C. G. Dunnells, F. J. Evans, F. M. McCullough, C. B. Stanton, H. A. Thomas.

NIDAY, LLOYD EDWARD, Gallipolis, Ohio. (Age 23.) Refers to G. H. Elbin, A. R. Webb.

NIELSEN, HANS EUGENE, Safford, Ariz. (Age 22.) Jun. Erosion Specialist with Eugene J., Carpenter. Refers to G. D. Clyde, O. W. Israelsen, R. B. West.

NIZENKOFF, CONSTANTIN CONSTANTINOVICH, Redmond, Wash. (Age 27.) Refers to I. L. Collier, G. E. Hawthorn, C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

ONGERTH, HENRY JOSEPH, San Francisco, Calif. (Age 22.) Rice Check Engr., U. S. Dept. of Agriculture. Refers to C. Derleth, Jr., C. G. Hyde.

OWLEY, ARTHUR NORMAN, Seattle, Wash. (Age 22.) Refers to C. C. May, C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

PASQUARIELLO, ARMAND JOSEPH, Newark, N.J. (Age 23.) Refers to A. Haring, C. T. Schwarze.

PETERSON, ARTHUR VINCENT, Ithaca, N.Y. (Age 22.) Graduate student, Cornell Univ. Refers to E. N. Burrows, S. C. Hollister.

PETTERSEN, EUGENE ARNT, Cranford, N.J. (Age 23.) Refers to R. C. Brumfield, C. V. Davis, F. E. Foss, G. Morrison, J. P. J. Williams.

PETTERSEN, PEDER GJERDT, Shawnee, Okla. (Age 37.) Res. Eng. Inspector, PWA, in Kansas and Oklahoma. Refers to B. Boyle, S. H. Conrad, R. E. Reed, J. S. Waldrep, G. Whittenberg, C. A. Winston.

PFLUCKER, WILFREDO DE AZPILCUETA, Peruvian Consulate, New York City. (Age 23.) Refers to R. P. Black, G. W. Sackett, F. C. Snow.

PUGSLEY, EDMOND BREWSTER, Seattle, Wash. (Age 21.) Refers to R. G. Hennes, C. C. More, R. M. Murray, O. A. Piper, F. H. Rhodes, Jr., M. O. Sylliaasen.

REGNIER, RAYMOND COBINGTON, Baltimore, Md. (Age 20.) Refers to J. H. Gregory, J. T. Thompson.

REYHOLEC, OTTO FRANK, White Plains, N.Y. (Age 21.) Refers to H. R. Codwise, L. F. Rader, E. J. Squire.

RHODES, BYRON LESLIE, Bradford, Pa. (Age 22.) Refers to F. M. McCullough, H. A. Thomas.

RICHARDS, IVAN FORD, Garland, Utah (Age 23.) Dist. Supervisor for Boxelder County, Utah. Refers to G. D. Clyde, O. W. Israelsen, H. R. Kepner, R. B. West.

RIEGELHUTH, WALTER MELVIN, San Francisco, Cal. (Age 23.) Refers to C. Derleth, Jr., B. A. Etcheverry, F. S. Foote, S. T. Harding, C. G. Hyde.

RIEPE, GERALD EUGENE, Kansas City, Kans. (Age 24.) Refers to J. S. Dodds, A. H Fuller, W. E. Galligan, F. Kerekes, L. O. Stewart.

RINNE, CLARENCE EMIL, Berkeley, Calif. (Age 21.) Asst. Engr. with W. L. Huber, Cons. Engr., San Francisco, Calif. Refers to B. A. Etcheverry, E. R. Huber, W. L. Huber, C. G. Hyde, E. M. Knapik.

ROBBINS, STANLEY EMERSON, Arlington, Mass. (Age 25.) Refers to H. P. Burden, F. N. Weaver.

SALMON, FRANK JOSEPH, Chattanooga, Tenn. (Age 24.) Refers to L. Mitchell, S. D. Sarason.

SARANIERO, EMIL JOSEPH, Brooklyn, N.Y. (Age 26.) Eng. Draftsman, Mech., Navy Dept., Bureau of Ordnance, Brooklyn, N.Y. Refers to F. E. Foss, G. Morrison, M. H. Van Buren.

SAUER, VICTOR WOODROW, Oakland, Calif. (Age 24.) Refers to R. E. Davis, F. S. Foote, W. Gottlieb, C. G. Hyde, B. Jameyson, E. J. Shaw.

SAXE, LOUIS STEINER, Mt. Vernon, N.Y. (Age 22.) Eng. Asst., Westchester Lighting Co. Refers to F. A. Barnes, J. E. Perry.

SCHULZ, WALTER GEORGE, Hobergs, Calif. (Age 24.) Refers to R. E. Davis, C. Derleth, Jr., B. A. Etcheverry, S. T. Harding. C. G. Hyde.

SCHWARTZENHAUER, ARTHUR GEORGE, Riggins, Idaho. (Age 29.) Refers to I. N. Carter, I. C. Crawford, J. W. Howard.

SEEBOTH, ALBERT JOSEPH, Minot, N.Dak. (Age 22.) Under Eng. Aide with U. S. Dept. of Agriculture, Bureau of Biological Survey. Refers to E. D. Roberts, F. W. Ullius.

SEEGER, WILLIAM ROBERT, San Francisco, Calif. (Age 22.) Refers to C. Derleth, Jr., C. G. Hyde.

SEELEY, HOWARD WILSON, JR., Cresson, Pa. (Age 22.) Engr. Apprentice, M. of W. Dept., Pennsylvania R.R., Pittsburgh, Pa. Refers to M. O. Fuller, H. G. Payrow, C. H. Sutherland, E. H. Uhler.

SELIGMANN, GUSTAV LEONARD, Los Angeles, Calif. (Age 34.) Planning Engr., State ERA. Refers to J. C. Allison, D. A. M. Blackburn, M. J. Dowd, J. N. Hendrickson, R. D. Spencer.

SHAW, VIRGIL EUGENE, Coral Gables, Fla. (Age 22.) Refers to R. E. Hutchins, R. L. McCormick.

SHEAHAN, RICHARD DAVID THOMAS, Brooklyn, N.Y. (Age 24.) Refers to H. P. Hammond, E. J. Squire.

SHELLEY, SIDNEY, Paterson, N.J. (Age 25.) Refers to W. J. Emmons, R. L. Morrison, W. C. Sadler.

SMITH, ALVA CECIL, Wilburton, Okla. (Age 25.) Chainman, Oklahoma State Highway Dept. Refers to J. E. Kirkham, E. R. Stapley.

SMITH, HERMAN SIDWELL, Iowa City, Iowa. (Age 21.) Draftsman, Water Resources Div., Iowa State Planning Board. Refers to A. H. Holt, R. B. Kittredge, B. J. Lambert, F. T. Mavis, H. E. Wessman, C. C. Williams.

SMITH, KENNETH ALAN, San Francisco, Calif. (Age 22.) With American Bridge Co. Refers to N. D. Morgan, C. E. Palmer.

SMITH, SIDNEY WILSON, Walnut Creek, Calif. (Age 22.) Refers to R. R. Arnold, C. Derleth, Jr., C. G. Hyde.

SMITH, WILLIAM ANDREW, JR., Washington, D.C. (Age 21.) Student Engr. in Highways, Div. of Management, U. S. Bureau of Public Roads, Washington, D.C. Refers to R. W. Crum, C. A. Hogentogler, J. R. Lapham.

SNOW, DEWITT MILLS, Seattle, Wash. (Age 21.) Refers to G. E. Hawthorn, C. C. May, C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

SOLLENBERGER, NORMAN JOHN, Manhattan, Kans. (Age 23.) Graduate Asst., Applied Mechanics Dept., Kansas State Coll. Refers to L. E. Conrad, E. R. Dawley, C. H. Scholer.

STERN, RICHARD MORRIS, Chicago, Ill. (Age 22.) Sales Div. (San. Eng.), International Filter Co. Refers to A. Boyd, E. F. Chandler.

SUZUKI, FUJITSUGU, Seattle, Wash. (Age 27.) Refers to I. L. Collier, C. W. Harris, C. C. More, F. H. Rhodes, Jr., R. G. Tyler.

SWARTZ, GUS JOSEPH, Minot, N.Dak. (Age 25.) Engr. Draftsman, Bureau of Agri. Eng., U. S. Dept. of Agriculture. Refers to G. McKinlay, D. W. Morrison, W. E. Smith, L. M. Winsor.

SWARTZ, ROBERT WALTER, Brooklyn, N.Y. (Age 20.) Refers to C. T. Schwarze, D. S. Trowbridge.

TARLTON, ELLIS ALVORD, Fairfield, Conn. (Age 22.) Refers to R. H. Suttie, J. C. Tracy.

THOMPSON, ROBERT JACKSON, La Grange, Ga. (Age 21.) Refers to C. D. Gibson, F. C. Snow.

TOMB, CHARLES EMERSON, Coopersburg, Pa. (Age 25.) Refers to M. O. Fuller, H. G. Payrow, C. H. Sutherland.

TONETTI, FREDERICK CHARLES, Long Island City, N.Y. (Age 23.) Refers to B. A. Bakhmeteff, A. H. Beyer, D. M. Burmister, J. K. Finch.

TURNER, HERBERT NOLAN, Ada, Okla. (Age 22.) With State Planning Board. Refers to J. E. Kirkham, E. R. Stapley.

VARGAS, JOSEPH ANTHONY, JR., Stonington, Conn. (Age 21.) Refers to C. D. Billmyer, J. L. Murray.

WAANANEN, ARVI OLAVI, West Concord, N.H. (Age 21.) Refers to E. W. Bowler, R. R. Skelton.

WALKER, WILLIAM POWELL, Ft. Myers, Fla. (Age 24.) Refers to C. C. Brown, R. M. Johnson, T. M. Lowe, P. L. Reed, W. L. Sawyer.

WAMSTAD, CHARLES OSCAR, Parma, Idaho. (Age 23.) Concrete Inspector, U. S. Bureau of Reclamation. Refers to I. C. Crawford, J. W. Howard, R. J. Newell.

WARWICK, PUTNAM RAND, Atlanta, Ga. (Age 22.) Refers to R. P. Black, F. C. Snow.

WATTERS, FRANK FAIRCHILD, Oakland, Calif. (Age 21.) Refers to B. A. Etcheverry, S. T. Harding, C. G. Hyde.

WEATHERS, HAROLD CLINTON, St. Joseph, La. (Age 22.) Hydrographic Draftsman, War Dept., Corps. of Engrs., U. S. Army. Refers to M. W. Furr, L. V. White.

Weggel, Harold Arthur, Bay City, Mich. (Age 24.) Field Engr., Consumers Power Co., Refers to R. H. Sherlock, C. O. Wisler.

Weikal, James Kenneth, Clark, Pa. (Age 21.) Refers to H. K. Kistler, E. D. Walker.

Weiner, Jesse, Columbia, S.C. (Age 20.) Laboratory Asst. and Material Inspector, Testing Laboratory, South Carolina Highway Dept. Refers to R. C. Johnson, W. E. Rowe, R. L. Sumwalt.

White, Kenneth Philip, Chattanooga, Tenn. (Age 22.) Refers to E. F. Berry, E. F. Church, L. Mitchell, S. D. Sarason.

Wigley, Arthur Browning, New Bern, N.C. (Age 24.) County Drainage Engr., Craven County, N.C. Refers to H. C. Bird, F. Kurtz.

Woelke, Walter Julius, Hardesty, Okla. (Age 24.) Bridge Foreman, Hyde Constr. Co., Enid, Okla. Refers to J. E. Kirkham, E. R. Stapley.

Woodhouse, Harry Herbert, New York City. (Age 46.) With ERB, B. P. Manhattan, Bureau of Eng. Refers to S. D. Brown, H. C. Ford, S. F. Holtzman, R. A. MacGregor, C. M. Pinckney, B. Schwerin.

Young, David Milson, Soda Springs, Idaho. (Age 25.) With Water Commr., Water Dist., No. 5, Soda Springs, Idaho. Refers to G. D. Clyde, O. W. Israelsen, H. R. Kepner, R. B. West.

Young, Lewis Alaric, Kansas City, Mo. (Age 29.) Engr. with Chas. A. Haskins, Cons. Engr. Refers to E. Boyce, R. A. Finney, C. A. Haskins, R. E. Lawrence, W. C. McNown, R. J. Paulette, R. O. Ruble, M. A. Wilson.

FOR TRANSFER

From the Grade of Associate Member

Brown, George Arthur, Assoc. M., Kankakee, Ill. (Elected Nov. 10, 1930.) (Age 35.) Sales Engr., Lehigh Stone Co., Kankakee, Ill. Refers to A. Engh, R. F. Fisher, A. H. Hunter, G. Jeppeson, H. E. Young.

Norcross, Theodore White, Assoc. M., Washington, D.C. (Elected Nov. 8, 1909.) (Age 52.) Chf. Engr., with U. S. Forest Service. Refers to C. H. Birdseye, H. K. Bishop, F. E. Bonner, W. Bowie, L. O. Colbert, C. N. Conner, C. D. Curtiss, G. E. Edgerton, F. H. Fowler, J. Frankland, N. C. Grover, J. C. Hoyt, W. L. Huber, E. Hyatt, E. W. Kramer, R. B. McWhorter, J. G. Staack, C. M. Upham.

Willard, Edwin Ruthven, Assoc. M., Seattle, Wash. (Elected Affiliate Nov. 21, 1921; Assoc. M. July 7, 1925.) (Age 43.) Special Agent (Engr.), Div. of Investigations, PWA. Refers to M. E. Clark, W. P. Greenawalt, F. H. Hardy, J. W. Miller, F. E. Roper, E. L. Warner.

From the Grade of Junior

Borton, Homer Thompson, Jun., Cleveland, Ohio. (Elected Nov. 14, 1927.) (Age 32.) Asst. Civ. Engr., Grade Crossing Dept., Cleveland, Ohio. Refers to W. P. Brown, G. B. Earnest, J. M. Heffelfinger, Jr., W. R. Hillyer, R. Hoffmann, F. H. Neff, F. L. Plummer.

Cant, George Francis, Jr., Jun., Kew Gardens, N.Y. (Elected Oct. 14, 1929.) (Age 32.) Refers to E. R. Cary, T. T. Davey, A. E. Howland, R. P. Lent, W. W. Rousseau, S. Shapiro.

Cox, George Francis, Jun., Tuckahoe, N.Y. (Elected Oct. 1, 1926.) (Age 31.) Jun. Asst. Engr., Grade 2, New York State Div. of Highways, Poughkeepsie, N.Y.; Asst. to County Asst. Engr., South Westchester County. Refers to F. J. Bonini, E. T. Cranch, E. H. Feldmann, F. C. Fox, Jr., C. A. Latimer, F. J. Laverty, W. C. Taylor.

Davidson, Edward Willoughby, Jr., Jun., Bremerton, Wash. (Elected Oct. 10, 1927.) (Age 32.) Engr.-Works Mgr., Kitsap County for CWA and Washington ERA. Refers to T. H. Campbell, J. Kylstra, C. C. More, C. A. W. Musson, W. D. Shannon, R. M. Warfield.

Fenn, Nathan Frederick, Jr., Jun., Bay Shore, N.Y. (Elected March 14, 1927.) (Age 33.) Vice-Pres., South Bay Consolidated Water Co. Refers to B. A. Bennett, F. W. Collins, A. W. Cuddeback, E. Devendorf, G. D. Norcom, H. N. Ogden, R. C. Taggart, T. H. Wiggin.

Gates, Howard Babcock, Jr., Jun., New York City. (Elected Dec. 16, 1929.) (Age 27.) Engr., Robert W. Hunt Co., Engrs. and Inspectors, New York City. Refers to O. H. Ammann, H. G. Balcom, L. W. Clark, R. Hoppen, Jr., T. R. Lawson, C. A. McCollough, R. W. McMullen, J. C. Ogden, D. B. Rush, G. A. Sallans, J. F. Sanborn, R. S. Saunders, R. H. Vose, R. F. Wheadon.

Hormann, Henry Fred, Jun., Brooklyn, N.Y. (Elected March 10, 1930.) (Age 29.) Asst. Engr., New York Edison Co., New York City. Refers to J. L. Bogart, W. H. Dieck, J. Farhi, F. W. Riegger, R. L. Sands, E. M. Van Norden.

Lange, George John Franklin, Jun., Newark, N.J. (Elected July 16, 1928.) (Age 32.) Wire Inspector, Golden Gate Bridge and Highway Dist. Refers to M. B. Case, C. M. Noble, H. R. Seely, M. T. Staples, E. W. Stearns, R. F. Wheadon.

Levy, Edwin Felix, Jun., San Francisco, Calif. (Elected Oct. 10, 1927.) (Age 30.) Jun. Bridge Designing Engr., San Francisco–Oakland Bay Bridge, Dept of Public Works, Div. of Highways, California. Refers to H. J. Brunnier, S. S. Gorman, J. W. Green, J. R. Kelsey, N. C. Raab, H. C. Wood, G. B. Woodruff.

Lindman, Bertram Herman, Jun., Olympia, Wash. (Elected Jan. 26, 1931.) (Age 28.) Eng. Economist, State Highway Cost Comm., Olympia, Wash. Refers to R. W. Finke, C. C. More, L. V. Murrow, R. G. Tyler, M. S. Woodin.

Madison, Knowles Knowlton, Jun., South Haven, Mich. (Elected Nov. 23, 1931.) (Age 32.) Jun. Engr., National Park Service. Refers to P. A. Fellows, L. M. Gram, W. S. Housel, R. H. Sherlock, H. A. Shuptrine, L. C. Smith, E. G. Willemin.

Moreland, James Brown, Jun., New York City. (Elected Dec. 14, 1925.) (Age 33.) With U. S. Coast and Geodetic Survey. Refers to J. P. Brooks, W. E. Brown, G. D. Cowie, C. R. Weaver, F. C. Wilson.

Rayburn, Elbert Brevard, Jr., Jun. Indianapolis, Ind. (Elected Dec. 16, 1929.) (Age 29.) Engr., Ready Mixed Concrete Corporation. Refers to S. W. Benham, C. M. DuBois, H. O. Garman, J. B. Hays, H. A. Tutewiler.

Schoolcraft, George Bingly, Jun., Austin, Ind. (Elected Oct. 30, 1933.) (Age 28.) Project Engr., Indiana State Highway Comm. Refers to F. A. Barnes, E. N. Burrows, J. T. Hallett, J. E. Perry, P. H. Underwood.

Stupka, Peter James, Jun. Washington, D.C. (Elected Nov. 11, 1929.) (Age 33.) Traffic Safety Engr., American Automobile Association, Washington, D.C. Refers to L. W. McIntyre, B. W. Marsh, C. S. Shaughnessy, H. S. Simpson, S. J. Williams.

The Board of Direction will consider the applications in this list not less than thirty days after the date of issue.

Men Available

These items are from information furnished by the Engineering Societies Employment Service, with offices in Chicago, New York, and San Francisco. The service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices, and the fee is to be found on page 87 of the 1935 Year Book of the Society. To expedite publication, notices should be sent direct to the Employment Service 31 West 39th Street, New York, N.Y. Employers should address replies to the key number, care of the New York Office, unless the word Chicago or San Francisco follows the key number, when it should be sent to the office designated.

Construction

Construction Engineer; Jun. Am. Soc. C.E.; 32; married; B.S. in C.E., New York University; enrolled Alexander Hamilton Institute business course; 5 years as contractor's engineer, costs and construction, bridges, roads, bulkheads, foundations; 4 years with telephone company, engineer in charge—50 miles of conduit construction, 35 miles of conduit rearrangements. Desires responsible position with future. C-5622.

Construction Engineer and Contractor; M. Am. Soc. C.E.; age 54; desires position with executive responsibility on hydro-electric development, dams, municipal improvements, paving, bridges, heavy excavation, and grading. Over 30 years responsible charge of design and construction of important works; thorough knowledge of economical methods of cost and efficient management. A-4827.

Engineer and Superintendent; Assoc. M. Am. Soc. C.E.; graduate civil engineer; 36; 16 years experience general construction—supervised construction of hospitals, hotels, theaters, and office buildings. Desires employment with contractor or corporation. Location immaterial. B-5434.

Design

Structural Engineer; M. Am. Soc. C.E.; thoroughly experienced in planning industrial buildings and in structural designs for architects; experience covers 20 years of work designing various types and sizes of buildings. Desires connection in or near New York City. B-929.

Executive

Graduate Civil Engineer and Licensed Attorney; Jun. Am. Soc. C.E.; single; 31; eight years active experience in field work, design, estimating and construction supervision. Qualified for, and especially interested in, concrete design, construction. Desires connection affording opportunity for rapid advancement upon demonstration of executive ability. Location not material. Available reasonable notice. D-4210.

Engineer; M. Am. Soc. C.E.; with experience on construction, investigation, and representation in 11 countries and on very large projects embodying a great diversity of activities, will engage by day, month, or year for work in any habitable locality. B-8480.

Civil Engineer; Assoc. M. Am. Soc. C.E.; desires position in any branch of civil engineering. Will also accept part-time research, compiling data; translations from Russian technical literature. Library experience for the last 18 months. Good knowledge of Russian literature. C-7182.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 34; graduate civil engineer; New York State professional engineers' license; 13 years experience, design and construction of industrial and engineering structures; general experience, architecture and engineering; experience covers engineering design, preparing estimates, bids, superintendence, management; responsible charge for engineers, contractors; bridge and heavy foundation work; thoroughly familiar all phases of work. D-3704.

CONSTRUCTION ENGINEER AND SURVEYOR; Assoc. M. Am. Soc. C.E.; 34; married; C.E. degree, Princeton University; completed Alexander Hamilton business course; 8 years on railroad surveys, construction, and maintenance; 3 years varied experience in construction, valuation, drafting, etc.; conscientious; adaptable. Connection with chance for advancement desired with reliable firm. Location immaterial. Available immediately. D-1027.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; college graduate; married; 15 years experience, triangulation, survey, railroad, railroad buildings, construction; sewer, drainage, bridges, grade crossings; heavy foundations, caissons, and reinforced concrete piles. In charge of laying out and inspection; contractor's and final estimate; design, artistic topographical, engineering, mechanical draftsman; 2 weeks notice. D-3628.

CIVIL ENGINEER; M. Am. Soc. C.E.; 49; 27 years experience, specializing in investigation, design, inspection, consultation, and construction of large hydro-electric projects in this country and abroad. Desires responsible position with engineering or contracting organization, designing or construction; can handle any phase of this work, including plant layout, cofferdams, installation of machinery, etc. B-70.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 29; married; B.S. in C.E., Manhattan College, 1927; 2 years experience drafting on subway construction; 4 years experience as transitman and chief of party; 1 year of experience on highway and bridge construction; desires position in any branch of civil engineering. Available immediately. D-3617.

GRADUATE COAL MINING ENGINEER AND GEOLOGIST; M. Am. Soc. C.E.; prominent Eastern university; for 34 years has successfully directed engineering departments of major anthracite and bituminous coal corporations; has specialized in examinations of virgin and operating properties; operating cost analyses, appraisals, prospectings, developments; permanent roof supports; mechanical mining, pneumatic, hydroelectric preparation; mining economics, haulage, drainage, ventilation, mine safety, employees' educational service. D-3678.

MANAGING ENGINEER; M. Am. Soc. C.E.; Pennsylvania state registration; exceptional record before this depression period in the supervision of engineering, fabricating plant operations, and sales for over 20 years. Desires opportunity to communicate with persons interested in obtaining a good man at a fair salary. C-5095.

CIVIL ENGINEER; M. Am. Soc. C.E.; age 41; graduate, Massachusetts Institute of Technology; civil engineering graduate; 11 years experience as foreman, superintendent, construction engineer on sewers, tunnels, subways, harbor work, earthwork, surveys; three years stadia; some knowledge steam and refrigeration; now available. D-4227.

JUNIOR

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 26; single; B.S., C.E., Carnegie Institute of Technology, 1932. About 2 years surveying experience with about 1 year as transitman on sewers, streets, and general topography. Desires opportunity in any branch of civil engineering. Willing to work. Location immaterial; Pittsburgh district preferred. Unemployed at present. Can report immediately. D-4195.

ENGINEER; Assoc. M. Am. Soc. C.E.; 29; married; B.S., Carnegie Institute of Technology; 8 years experience with public utility in hydroelectric investigations, electrical distribution engineering, cost analysis, appraisals, and estimating. Also teaching experience in mathematics. Capable of directing engineering investigations. Available on short notice. D-1157.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 24; single; 4 months topographic surveying; 3 months U. S. Coast and Geodetic Survey. Desires opportunity in any branch of civil engineering. Salary secondary. Vicinity of New York preferred but can go anywhere. Available immediately. D-4098.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; New Jersey License; M. Sc. in C.E., Rutgers University, 1935; 8 years experience in construction. Can handle men. Chief interests: structures, highways, surveying, and sanitation. Will also consider teaching. Prefer New York or vicinity but will go anywhere. Initial salary secondary, if connection is permanent. D-4146.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; single; B.S. in C.E., 1933. Majored in structural steel design and water supply. Experience water and sewage works; geodetic survey. Desires opportunity in any branch of civil engineering. Location immaterial. Available on short notice. D-2683.

Civil Engineer; Jun. Am. Soc. C.E.; graduate of Yale University; 28; single; 4 years experience in all phases of gold-lode mining in California, including construction; competent to make mine examinations and operate properties; desires a connection with some soundly financed young mining organization or with some construction firm. C-5760.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 28; married; B.S., U. S. Military Academy, 1928; C.E., 1932; M.C.E., Cornell University, 1933; experience covers topographic surveys, hydrographic surveys, economic studies of waterways, flood control studies, hydraulic research, river improvement. Particularly interested in hydraulic research. Desires permanent position. Location, temperate zone. Available immediately. D-4234.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; married; age 31. Experience: two years highway, one year structural, one year mining, and one year civil engineering. Education: B.S. in civil engineering and graduate study in structural and sanitary engineering. Good references. Location, United States or foreign. C-3977.

RECENT GRADUATE; Jun. Am. Soc. C.E.; M.C.E.; 24; single; two years as graduate scholar in civil engineering department. Engineering economics and structural engineering principal fields of interest. Position as instructor or graduate assistant desired. Experience teaching resistance of materials and as assistant in civil engineering laboratory and surveying courses. D-2990.

SALES

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 10 years in the United States; graduate in business management. Now resident abroad with finest connections. Receptive to negotiations for association with American concern wishing representation in the Scandinavian countries. Investigations, reports, translations, advertising, research. C-5983.

CIVIL ENGINEER; Assoc. M. Soc. C.E.; 15 years sales engineering experience; acquainted with public works officials and contractors throughout East; will consider representing manufacturers of meritorious public works products; has own office. B-5401.

TEACHING

CIVIL ENGINEER; M. Am. Soc. C.E.; S.P.E.E.; Methodist Church; Masonic Lodge; degrees, B.S. in C.E., C.E., and M.S. Major in structural engineering, minor in highway engineering; age 44; 6 years varied practical experience; 13 years successful teaching experience; 9 years as village engineer. Desires position teaching civil engineering or applied mechanics. D-302.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; married; B.S. in C.E., Massachusetts Institute of Technology; M.S. in C.E., Yale University; recent graduate study at Massachusetts Institute of Technology; 10½ years practical experience in design and construction of bridges, buildings, and dams; 10 years teaching structural engineering, concrete, and descriptive geometry at leading university. B-3516.

RECENT BOOKS

New books of interest to Civil Engineers, donated by the publishers to the Engineering Societies Library, or to the Society's Reading Room, will be found listed here. A comprehensive statement regarding the service which the Library makes available to members is to be found on page 77 of the Year Book for 1935. The notes regarding the books are taken from the books themselves, and this Society is not responsible for them.

DEUTSCHES MUSEUM, ABHANDLUNGEN UND BERICHTE, Jg. 7, Heft 1. Kulturförderung durch Technik und Wissenschaft. By J. Zenneck. Berlin, VDI-Verlag, 1935. 20 pp., illus., 8 × 6 in., paper, 0.90 rm.

A popular lecture in which, by means of selected examples, attention is called to some of the contributions of science and engineering to civilization. The microscope, photography, radio, and the facilitation of transportation are the examples used.

FESTIGKEITSLEHRE MITTELS SPANNUNGSOPTIK. By L. Föppl and H. Neuber. Munich and Berlin, R. Oldenbourg, 1935. 115 pp., illus., diagrs., charts, tables, 9 × 6 in., paper, 6.60 rm.

The lack of any German book on photoelasticity has provided the reason for this small work, which presents the theoretical principles of the method, describes the interpretation of its results, and shows its uses in studying the strength of materials. The book is based on the experience of the Mechanical Engineering Laboratory of the Munich Technical High School.

MACHINE DESIGNERS GUIDE, Formulas, Mechanics, Graphics, Strength of Materials, Examples. By K. W. Najder. Ann Arbor, Mich., Edwards Brothers, 1935. 198 pp., diagrs., charts, tables, 9 × 5 in., cloth.

A collection of mathematical and mechanical tables and formulas frequently needed by machine designers and draftsmen. The formulas avoid higher mathematics, and the book may be used by designers of limited engineering education.

NATIONAL PHYSICAL LABORATORY, REPORT FOR THE YEAR 1934. London, Department of Scientific and Industrial Research. His Majesty's Stationery Office, 1935. 260 pp., illus., diagrs., charts, tables, 11 × 8 in., paper, 13s.

This volume contains a concise report on the work done in the fields of physics, electricity, radio, meteorology, engineering, metallurgy, aerodynamics, and hydrodynamics. The various investigations are described briefly and the results summarized. A list of papers published by the laboratory and the staff is included.

SIPHON SPILLWAYS. By A. H. Naylor. London, Edward Arnold and Company; New York, Longmans, Green and Company, 1935. 83 pp., illus., diagrs., charts, tables, 9 × 6 in., cloth, $3.40.

The recent construction of the first two large siphon spillways in Great Britain has resulted in the production of this short treatise, the first upon the subject. The first part of the book describes the various types of siphons, the second discusses design. The design of the Laggan Dam siphon spillway is described, step by step.

TREATISE ON SURVEYING, Vol. 1. Compiled by R. E. Middleton and O. Chadwick. 5 ed. rev. By N. T. M. Ormsby. London, E. & F. N. Spon; New York, Engineers Book Shop, 1935. 398 pp., illus., diagrs., charts, tables, maps, 8 × 5 in., leather, $4.

This well-known English textbook aims to provide a course in surveying which will adequately equip the student for any kind of work. The present volume covers the work usually called for in countries already mapped. To the new edition, a section on mass-haul has been added, and those on transition and vertical curves have been rewritten.

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